REVIEW ARTICLE

Is open surgery for head and neck cancers truly declining?

**Dana M. Hartl · Daniel F. Brasnu · Jatin P. Shah · Michael L. Hinni · Robert P. Takes ·
Kerry D. Olsen · Luiz P. Kowalski · Juan P. Rodrigo · Primož Strojan ·
Gregory T. Wolf · Alessandra Rinaldo · Carlos Suárez · William M. Mendenhall ·
Vinidh Paleri · Arlene A. Forastiere · Jochen A. Werner · Alfio Ferlito**

Abstract   In the past two decades, major modifications in
the way we treat head and neck cancers, due to advances in
technology and medical oncology, have led to a decline
in the use of open surgery as first-line treatment of cancers
arising from several primary tumor sites. The incidence of
tobacco- and alcohol-related squamous cell carcinoma of
the pharynx and larynx has been steadily decreasing, with a
rise in the incidence of human papillomavirus-related
oropharyngeal tumors and the use of minimally invasive
endoscopic surgery and non-surgical treatment modalities
has increased in the treatment of all of these tumors.
However, open surgery remains the initial definitive
treatment modality for other tumors, including tumors of
the skin, oral cavity, sinonasal cavities and skull base,
salivary glands, thyroid and sarcomas. Selected group of
nasal, paranasal, base of the skull and thyroid tumors are
also candidates for minimally invasive procedures. For

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Head and Neck Scientific Group (http://www.IHNSG.com).

D. M. Hartl
Department of Otolaryngology-Head and Neck Surgery,
Institut Gustave Roussy, Villejuif Cedex, France

D. M. Hartl
Laboratoire de Phonétique et de Phonologie,
Sorbonne Nouvelle, Paris, France

D. F. Brasnu
Department of Otolaryngology-Head and Neck Surgery,
and Voice, Biomaterials and Head and Neck Oncology Research
Laboratory, University Paris V, European Hospital Georges
Pompidou, Paris Cedex, France

J. P. Shah
Head and Neck Service, Memorial Sloan-Kettering
Cancer Center, New York, NY, USA

M. L. Hinni
Department of Otolaryngology-Head and Neck Surgery,
Mayo Clinic, Phoenix, AZ, USA

R. P. Takes
Department of Otolaryngology-Head and Neck Surgery,
Radboud University Nijmegen Medical Center, Nijmegen,
The Netherlands

K. D. Olsen
Department of Otorhinolaryngology, Mayo Clinic,
Rochester, MN, USA

L. P. Kowalski
Department Otorhinolaryngology-Head and Neck Surgery,
Centro de Tratamento e Pesquisa Hospital do Cancer A.C.
Camargo, São Paulo, Brazil

J. P. Rodrigo · C. Suárez
Department of Otolaryngology, Hospital Universitario
Central de Asturias, Oviedo, Spain

J. P. Rodrigo · C. Suárez
Instituto Universitario de Oncología del Principado
de Asturias, Oviedo, Spain

P. Strojan
Department of Radiation Oncology, Institute of Oncology,
Ljubljana, Slovenia

G. T. Wolf
Department of Otolaryngology-Head and Neck Surgery,
University of Michigan, Ann Arbor, MI, USA

A. Rinaldo · A. Ferlito (✉)
ENT Clinic, University of Udine, Udine, Italy
e-mail: a.ferlito@uniud.it

W. M. Mendenhall
Department of Radiation Oncology, University of Florida,
Gainesville, FL, USA

some indications, the rate of open surgery has actually increased in the past decade, with an increase in the incidence of oral cavity, thyroid and skin cancer, an increase in the number of neck dissections performed, and an increase in salvage surgery and free flap reconstruction. The use of minimally invasive, technology-based surgery—with the use of lasers, operating microscopes, endoscopes, robots and image guidance—has increased. Technology, epidemiology and advances in other domains such as tissue engineering and allotransplantations may further change the domains of competencies for future head and neck surgeons.

Introduction

In the past two decades, there has been a major transformation in the way we treat many head and neck squamous cell carcinomas (HNSCCs), including a decline in the use of open surgery as first-line treatment for a certain proportion of these tumors [1–3]. This evolution has been brought about several factors. First, from an epidemiological standpoint, the incidence of HNSCC has been decreasing in most developed countries thanks in part to public health agencies' efforts to decrease tobacco consumption. Second, advances in chemotherapy and radiation therapy have lead to highly effective non-surgical regimens for patients with advanced laryngeal and pharyngeal tumors, with the added advantage of laryngeal preservation in many cases. In addition, the incidence of radiochemosensitive oropharyngeal human papillomavirus (HPV)-related squamous carcinoma is increasing. Third, technological advances with the widespread availability of operating microscopes, endoscopes, lasers, image-guided surgery and more recently robotics, is transforming our surgical approaches, with transoral and transnasal minimally invasive techniques

V. Paleri
Department of Otolaryngology-Head and Neck Surgery, Newcastle upon Tyne Foundation Hospitals, NHS Trust, Newcastle upon Tyne, UK

A. A. Forastiere
Department of Oncology, The Sidney Kimmel Comprehensive Cancer Center, Johns Hopkins University School of Medicine, Baltimore, MD, USA

J. A. Werner
Department of Otolaryngology-Head and Neck Surgery, Philipp University, Marburg, Germany

greatly improving the postoperative course and functional outcomes for selected tumors.

These three factors contributing to the decrease in open surgery are related mostly to laryngeal and pharyngeal squamous cell carcinoma (and some sinonasal, skull base and thyroid cancers). However, the epidemiological evolution in developed countries is not mirrored in other countries or for other tumor sites. There are other locations and histopathological types of cancers for which open surgery is still the primary treatment, such as oral cavity, thyroid, skin and salivary glands, and the indication for open surgery performed by head and neck surgeons is actually increasing for some tumors, such as thyroid cancer and squamous cell carcinoma of the skin metastatic to regional lymph nodes. Finally, an increasing proportion of the open surgery now performed for HNSCC involves salvage surgery following unsuccessful chemoradiation or performed for second primaries in previously irradiated fields or major resections requiring complex reconstructions.

We have thus chosen to discuss these changes in the use of open surgery in the most prevalent head and neck cancer sites and to provide some insight into future surgical training needs.

The declining use of open surgery

The declining use of open surgery for some head and neck tumor sites is attributable in part to a declining incidence of HNSCC over the past few decades due to changes in alcohol and tobacco consumption [4]. A declining incidence in the USA between 1975 and 2001 has been shown for the hypopharynx (with a 35 % decrease), the non-tonsillar oropharyngeal mucosa (with a 26 % decrease), and the larynx (with a 26 % decrease) [5]. Between 1990 and 2006 in England, the incidence of head and neck cancer decreased by 20 %, leveling off in the last 5 years [6]. More recently, from 1998 to 2002, a decrease in the incidence of laryngeal carcinoma was also observed in Latin America, Asia, Australia, Finland and Sweden, yet with an increase in incidence was observed in Japan, Denmark, Norway and for females in Spain and France [7, 8]. Squamous cell carcinoma of the oral cavity and pharynx decreased in the USA over the same period [7]. On the contrary, however, cancers of the oral cavity actually increased in Northern and Eastern Europe and for women in Western Europe over the period 1998–2002, but between 1970 and 2007, mortality from these cancers has decreased in Europe in general [4].

The incidence of oropharyngeal tumors, particularly those arising from the tonsil or tongue base, has been increasing in many countries including the USA [9], Canada [10], Australia [11], Denmark [12], Sweden [13],

England [6], and France [8], with a spectacular increase in the proportion of oropharyngeal cancers harboring evidence of HPV infection. It is predicted that HPV-related oropharyngeal cancers will surpass non-HPV-related cancers by the year 2020 and the incidence in the USA will approach that of uterine cervical cancer [13, 14].

The declining use of open surgery as first-line treatment for laryngeal cancer over the past two decades is also due to the widespread use of minimally invasive transoral laser micro-surgery (TLM), for patients with early to mid-stage cancers, and to the implementation of non-surgical organ preservation strategies for patients with higher-stage tumors [1]. For glottic tumors classified as T1a [15], conventional external beam radiation therapy has been a standard of care for several decades [16, 17], but since the 1990s TLM has also been adopted as standard initial treatment for these tumors, and included in national guidelines in the United Kingdom [1, 18]. Current evidence shows no significant difference in terms of oncologic outcomes between these two approaches for T1a glottic carcinoma [19]. Functional results are also reported to be similar when radiotherapy is compared to transoral laser resection for T1 glottic carcinoma [20].

Open organ preservation surgery (conservation surgery) as first-line treatment provides better local control for T2 laryngeal tumors with impaired mobility as compared to radiation therapy alone [21]. Chemoradiation has been shown to improve local control and survival as compared to radiation therapy alone [22], but data comparing open organ preservations surgery with chemoradiation for this subgroup of patients is lacking. Thus, the current standard of care for selected patients with intermediate stage cancers is either open organ preservation surgery or radiotherapy. Chemoradiation is usually considered for selected patients with more advanced T2N1-3 tumors [23], but TLM may be considered a first-line treatment for selected cases in experienced centers. The downside to the decreasing use of open conservation surgery for laryngeal cancer in general is that there is a decrease in the number of surgeons and centers with experience in open conservation laryngeal surgery. The expertise of open partial laryngectomies is lacking in some areas, and may disappear in the future from lack of training of young surgeons. Thus, many centers even today employ chemoradiation systematically for cases which may be suitable for open partial laryngectomy. Furthermore, open partial surgery in recurrent cancer may be performed for selected cases, an important reason why this skill set should be maintained [24].

Finally, for more advanced tumors (most T3 and selected T4) requiring a total laryngectomy if surgery were to be performed, non-surgical organ preservation strategies have been the standard of care for approximately the last two decades, with the oncologic results of total laryngectomy remaining the gold standard. For more advanced lesions, total laryngectomy is still the treatment of choice. The seminal Veterans Administration trial comparing induction chemotherapy followed by radiation therapy in responders to first-line total laryngectomy showed that a functional larynx can be preserved in almost two-third of patients, without a decrease in overall survival [25]. Today, concurrent chemoradiation is recommended for organ preservation, following the results of the three-arm randomized trial (RTOG 91-11) that excluded most T4 tumors published by Forastiere et al. [22], in which concurrent chemoradiation was shown to be superior to radiation therapy alone but also to induction chemotherapy for organ preservation, without compromising survival. New paradigms for sequential therapy using taxanes and targeted molecular therapy are still under investigation, however, and may replace current protocols in the near future [26, 27]. A caveat of chemoradiation therapy is that patients with high-volume laryngeal cancers and those with significant cartilage destruction are unlikely to be cured with chemoradiation and, if they are, are likely to have a dysfunctional larynx associated with laryngeal fibrosis, causing aspiration and dysphagia, often severe enough to require a tracheostomy and a gastrostomy. These patients may be better treated with an initial total laryngectomy and postoperative irradiation (see below).

For patients with hypopharyngeal cancer, as for laryngeal cancer, non-surgical organ preservation strategies have contributed to the decline in primary open surgery, although, as for laryngeal cancer, advanced tumors are still more often better managed with surgery. For the rare tumors amenable to surgical resection with preservation of laryngeal function, transoral laser surgery has largely supplanted open surgery, due to the more favorable postoperative course, without compromising the oncologic results in selected cases for experienced surgical teams [2, 28]. More recently, reports indicate that selected tumors may also be approached transorally with robotic assistance without compromising oncologic outcomes [29]. For tumors requiring a total laryngectomy with pharyngectomy, there are very few controlled trials focusing only on hypopharyngeal tumors. One of these compared first-line surgery to non-surgical organ preservation based on induction chemotherapy with radiation therapy for responders [30]. The 10-year results found no difference in terms of overall survival (13 %) or progression free survival (8–10 %) between the two treatment arms, but half of the surviving patients at 10 years were surviving with a functional larynx. In a recent meta-analysis of over 16,000 patients, chemotherapy with cisplatin added to the treatment regimen was shown to offer a 4 % improvement in survival for patients with hypopharyngeal cancer, as compared to radiation therapy alone [31]. There was no

significant difference in this study, however, between the benefit of concurrent chemoradiation as compared to induction chemotherapy for hypopharyngeal tumors. Newer studies with the addition of taxanes to induction chemotherapy have shown an increase in the rate of response to chemotherapy and an increase in laryngeal preservation for patients with advanced tumors (including hypopharyngeal tumors) with no improvement in overall survival, however [26, 32].

There are no studies directly comparing concurrent chemoradiation with induction chemotherapy regimens for hypopharyngeal cancer specifically. However, the use of concurrent chemoradiation for organ preservation for hypopharyngeal carcinoma is based on the results of the larynx preservation trial published by Forastiere et al. [22], as previously mentioned, in which concurrent chemoradiation was superior to induction chemotherapy and to radiation therapy alone. Thus, non-surgical organ preservation, with induction protocols or concurrent chemoradiation, has been widely accepted within the last decade as first-line treatment in many cases of hypopharyngeal cancer, to optimize organ preservation with no detriment to overall survival. However, as in the case of high-volume laryngeal cancers, unfavorable T3–T4 hypopharyngeal cancers are probably best treated by total laryngectomy with partial or total pharyngectomy and postoperative irradiation.

The use of open surgery in the initial treatment for oropharyngeal cancer has also been declining in the past 2–3 decades [3]. Radiotherapy or concurrent chemoradiation for advanced disease has become the standard of care for most oropharyngeal lesions with the aim to avoid mandible-splitting surgery with flap reconstructions and the functional morbidity commonly associated with it, although there are no controlled studies directly comparing oncologic or functional outcomes of (chemo)radiation or quality of life as compared to first-line surgery. The oncologic results of (chemo)radiation have been shown to be comparable, however, to historic surgical cohorts, and the reported functional results more favorable. The decline in the incidence of tobacco- and alcohol-related oropharyngeal squamous cell carcinoma has been accompanied by a rapid increase in HPV-associated oropharyngeal cancers [13, 33, 34]. The oncologic outcomes of concurrent chemoradiation for these tumors are better than for non-HPV-related tumors [35]. In addition, HPV-associated tumors arise in patients who are younger, less likely to have severe comorbidities and less likely to have metachronous second primaries, making non-surgical treatment in many cases the therapy of choice, for oncologic and functional reasons. HPV-related cancers tend to have a very favorable prognosis with few local failures. Most treatment failures are related to distant disease. These cancers tend to be sensitive to both chemotherapy and radiation. Combined chemoradiation, however, is associated with significant morbidity,

similar to that seen with chemoradiation approaches for laryngeal cancer, with almost 43 % of patients developing late complications such as fibrosis, stenosis and dysphagia, leading to death in some cases [36]. It remains to be seen if radiation alone or surgical excisions alone or with adjuvant radiation therapy can provide comparably high success rates in this subset of oropharyngeal cancer patients.

For selected oropharyngeal tumors, TLM has also been shown to provide comparable oncologic outcomes with low morbidity, and thus has also become the standard of care in experienced centers for a subset of patients [37]. Even more recently, transoral robotic-assisted surgery (TORS) has been studied in the treatment of selected oropharyngeal tumors, including stages III and IV [38]. This approach for selected tumors has been shown to provide excellent oncologic results with low morbidity [39]. In most cases, postoperative radiation has been added to surgery based on either close surgical margins or the presence of advanced cervical metastases. Although most currently reported cohorts are small and the follow-up limited, the minimally invasive functional approach with primary surgery is promising in that some patients may avoid adjuvant radiation therapy or chemoradiation, further improving functional results. The reported long-term oncologic and functional results for TORS with or without adjuvant radiation therapy for selected advanced-stage oropharyngeal cancers are encouraging [37, 40]. This approach also has been shown to be as effective for HPV-related tumors as for non-HPV-related tumors [41].

Although the indications for open surgery as first-line treatment have been decreasing over the last few decades, transoral surgery and non-surgical organ preservation protocols have been the standard of care at least for the last decade, without other major modifications in treatment paradigms. The decline in the use of initial open surgery, as demonstrated by the absence of publications on the subject in recent years [1], has most probably stabilized, and any further decline may simply be related to the overall decreasing incidence of the tobacco- and alcohol-related cancers as well as earlier diagnosis. The continued developments in robotic surgery, such as the future use of single portal devices, and increasing training, experience and availability of minimally invasive approaches may in the future change the standard treatment paradigms for some patients back to primary, but minimally invasive, surgical treatment because of reduced morbidity as compared to intensive chemoradiation approaches.

The continuing use of open surgery

Despite the shift toward minimally invasive surgery and other non-surgical treatments over the past 10–20 years,

open surgery is still the standard of care first-line treatment for patients with advanced pharyngeal and laryngeal tumors, and for some head and neck tumors in specific HNSCC locations, such as the oral cavity, the sinonasal cavities, the skull base, thyroid and salivary glands, and for some histopathological subtypes other than squamous cell carcinoma, such as adenocarcinomas, sarcomas and melanoma and non-melanoma skin cancer. Moreover, with an increasing incidence of cutaneous squamous cell cancer, which predominantly arises in the skin of the head and neck, the number of patients requiring neck dissections and parotidectomies has risen as these tumors may metastasize to the lymph nodes in the neck and parotid gland [42].

For patients with advanced laryngeal and hypopharyngeal squamous cell carcinoma, the use of initial concomitant chemoradiation (or inclusion in organ preservation clinical trials) is based on randomized controlled trials showing that these approaches improve laryngeal preservation without adversely affecting survival. Some of these randomized trials, however, excluded patients with extensive laryngeal cartilage invasion or significant involvement of the tongue base, favoring "low-volume" advanced tumors, and many with normal vocal fold mobility [22, 43]. For the Veterans Affairs study [25], where definitive management was radiation alone for responders after induction chemotherapy, even the most advanced cancer patients were eligible, with over 25 % requiring a tracheostomy and many having gross cartilage destruction. However, these patients were excluded from subsequent trials of organ preservation. This implies that we really do not know the oncologic outcomes of current chemoradiation protocols for truly extensive tumors of the larynx and the hypopharynx with cartilage destruction and/or a fixed vocal fold.

On the other hand, long-term prospective results of a phase II clinical trial using chemotherapy to select patients for subsequent chemoradiation based on a favorable response to a single cycle of induction chemotherapy rather than committing every patient to chemoradiation were very encouraging even though over 70 % of the patients had radiologic gross cartilage invasion [44].

The results of two large retrospective studies of advanced laryngeal cancer imply that a total laryngectomy may confer an advantage in terms of overall survival as compared to primary chemoradiation. The database study by Chen and Halpern [45] of 7,019 patients found that the patients with stage IV tumors treated with initial chemoradiation had a higher risk of death (hazard ratio 1.43) as compared to those treated initially with a total laryngectomy. These results were confirmed in a more recent work that included over 50,000 patients with advanced laryngeal cancer from the United States National Cancer Database

(NCDB) [46]. In this study, patients with advanced-stage laryngeal cancer receiving chemoradiation had higher risks of death (hazard ratio 1.13) as compared to patients treated with laryngectomy.

In another review from the NCDB, Hoffman et al. [47] analyzed data from 158,426 cases of laryngeal squamous cell carcinoma. This review of data identified a trend toward decreasing survival among patients with laryngeal cancer. Patterns of initial management across the same period indicated an increase in the use of chemoradiation with a decrease in the use of surgery despite an increase in the use of endoscopic resection. Initial treatment of T3N0M0 laryngeal cancer resulted in a poorer 5-year relative survival for those receiving either chemoradiation (59.2 %) or irradiation alone (42.7 %) when compared with that of patients after surgery with irradiation (65.2 %) and surgery alone (63.3 %). It is conceivable that this decline in survival could be linked to trends to perform less aggressive primary site surgery by avoiding total laryngectomy and less aggressive neck surgery by diminishing the use of radical or comprehensive neck dissections. In addition, in a comparative multi-center study, TLM produced equivalent overall survival but superior disease free survival and local control compared to the chemoradiation arm of the RTOG 91-11 trial as previously mentioned [22, 48, 49]. Finally, a cohort study published by Gourin et al. [50] included 195 patients with stage IV laryngeal cancer. The hazard ratio for death in the group of patients treated with chemoradiation was 3.5 as compared to those treated initially with a total laryngectomy.

Of course, there may be biases in these retrospective studies. It is possible that patients with low performance status were preferentially treated with initial chemoradiation, or that salvage surgery for patients experiencing local failure after chemoradiation were diagnosed too late for successful surgery, for example. Despite the drawbacks of these reports, for patients with very extensive hypopharyngeal and laryngeal tumors, the results of currently published randomized trials may not be applicable, and a total laryngectomy with adjuvant radiation therapy or adjuvant chemoradiation may still be preferable for such patients, in terms of survival. Moreover, functional outcomes in cases of non-surgical treatment of an already non-functional larynx will be poor: although being cured of their cancer, many patients with a non-functional larynx will end up with total laryngectomy. Therefore, in situations where the larynx is already non-functional due to tumor extension, a total laryngectomy will remain the first choice as treatment.

For HNSCC locations such as the oral cavity, nasal cavity and paranasal sinuses, open surgery or transoral resection remains the standard first-line treatment. Furthermore, the need for surgery for oral cavity squamous

cell carcinoma may actually be increasing in some geographic areas due to a reported increased incidence of these tumors, particularly in Northern and Eastern Europe and Japan, and an increased incidence for women in Western Europe [7]. Complete surgical resection also remains the gold standard in the management of skull base tumors and sinonasal tumors, although selected patients may be amenable to endoscopic tumor resection which improves the postoperative course and functional outcomes [51, 52].

Finally, open surgery still plays a major role as the standard of care for rarer types of tumors in the head and neck such as sarcomas, skull base tumors, salivary gland tumors and melanoma and non-melanoma skin cancer and their regional metastases. The incidence of salivary gland tumors seems to be stable over the last 15 years in the USA [53], but this stability may not be present in other countries. In England, salivary gland cancer incidence has increased by around 37 % between 1990 and 2006 [6]. A recent cancer registry study in Germany, e.g., found that the rate of salivary cancers actually increased for males during the period 1996–2005 [54]. On the contrary, a Spanish registry study found a decrease in the incidence of major salivary gland cancer in the period from 1991 to 2001 [55]. With the incidence of these tumors increasing with age [56], we may see more of these tumors in the next few years due to the increase in the elderly population in Western countries.

The increasing use of open surgery

The literature contains some indications that the overall rate of primary surgery for HNSCC and other types of tumors may actually be increasing. Gourin and Frick [57, 58] recently published two large database studies of surgical care for laryngeal and oropharyngeal cancer in the USA. The aim of both studies was to evaluate the relationship between surgeon and hospital volumes, short-term postoperative outcomes and costs. Both studies compared the two successive 7-year periods 1993–2000 and 2001–2008 with data from the Nationwide Inpatient Sample database which includes approximately eight million hospital stays per year.

For oropharyngeal cancer, the average annual number of surgical cases increased by 8 % in 2001–2008 as compared to 1993–2000 [58]. The number of neck dissections increased from representing 70 % of the surgical cases to 76 % ($p = .01$) and tonsillectomies increased from 15 to 19 % ($p = .0001$). The proportion of cases with previous radiation therapy increased from 3 to 5 % ($p = .02$), as did the proportion of patients with a comorbidity score >3. Although the complication rate decreased between the two periods, the proportion of pharyngocutaneous fistulas increased from 21 % of the complications to 53 %

($p < .001$). The proportion of cases in high-volume teaching hospitals increased from 71 to 76 % ($p = .04$).

For laryngeal cancer, between the two 7-year periods, the average annual number of surgical cases decreased by 22 % [57]. The number of total and partial laryngectomies decreased, but total laryngectomy remained the most common surgical procedure, representing 73 % of cases in 1993–2000 and 71 % in 2001–2008. The number of neck dissections and free flaps increased between the two time periods, however, from 10 to 13 % of procedures for neck dissection ($p = .01$) and from 4 to 7 % for free flaps. As for oropharyngeal carcinomas, the number of patients having received prior radiation therapy increased, as did the postoperative fistula rate and the rate of high comorbidity scores, although the global complication rate decreased. Finally, as for oropharyngeal cancer, the proportion of cases treated by high-volume surgeons in high-volume teaching hospitals increased.

These observations imply that, although initial open surgery for some cancers is decreasing, open surgery itself may not be decreasing at a rate as fast as we may think. Salvage surgery after concomitant chemoradiation therapy for patients with HNSCCs is challenging because of its associated morbidity and mortality and the poor prognosis of these patients. Many patients with recurrence are unsuitable, however, for salvage surgery due to local tumor extensions leading to unresectability or due to distant metastases. Thus, in different series of head and neck carcinomas, only 30–40 % of patients with failure after chemoradiation were considered for salvage surgery [59–61]. Usually, salvage surgery involves extensive resections, requiring reconstructive techniques with regional or free flaps in most cases, and with more difficult postoperative management, as attested by the increase in the fistula rate. Transoral surgery may also be feasible in selected cases and in experienced centers for salvage therapy [62]. Disease control after salvage surgery is low and depends on the stage and anatomic location of the tumor. A 5-year adjusted survival of 17–43 % has been reported after salvage surgery [60–63] and is related to initial tumor stage and concurrent local and regional failures [60]. Another observation is that, although the primary tumors are resected transorally in an increasing number of cases, neck dissection (elective or therapeutic) remains an open surgical procedure that is an essential part of the treatment of these cancers. Salvage neck dissection for persistent disease after chemoradiation may also increase in the future.

Another Nationwide Inpatient Sample database studied the trends in the rate of neck dissections, comparing the years 2000, 2004 and 2006 [64]. A 26 % increase in the total number of inpatient neck dissections was seen between 2000 and 2006. Approximately 75 % of this increase was due to neck dissections performed for thyroid

and cutaneous neoplasms, but 25 % was due to an increase in neck dissections performed for oral cavity primaries. With the increasing incidence of thyroid [65, 66] and cutaneous cancers [67] and an increase in oral cavity cancers in some countries (see above), this trend will probably continue.

Finally, it is well established that the incidence of thyroid cancer is increasing—both microcarcinoma and higher-stage tumors [65, 68]—and open surgery for thyroid cancer is still the first-line treatment with curative intent for adequate tumor and lymph node resection. Locally invasive thyroid cancers may require complex laryngotracheal resections and conservation laryngeal surgery, which requires an intimate knowledge of the anatomy and physiology of the larynx and pharynx, to optimize oncologic and functional results. Minimally invasive video-assisted thyroidectomy, endoscopic thyroidectomy or robot-assisted endoscopic thyroidectomy have a limited role at present, and except for a few highly specialized centers, the indications do not go beyond thyroid microcarcinoma [69, 70].

In the future?

Despite the decreasing rate of open surgery as the primary initial treatment for some head and neck cancer patients as compared to 20 years ago, this is an exciting time for head and neck surgeons whose role in the diagnosis, treatment and follow-up of head and neck tumors remains firmly established and fully relevant. Surgeons must continue to fully participate in the development of new therapeutic approaches and are an integral part of the multidisciplinary team.

Head and neck surgeons today generally perform more difficult salvage surgery and reconstruction procedures using free flaps than 20 years ago, and this trend will probably not subside any time in the near future. The trend toward higher volume surgeons working in higher volume teaching hospitals will continue as well, due to the improved medical and economic outcomes obtained from these centers [57, 58]. Work in large centers also facilitates multidisciplinary teamwork which is fundamental to optimizing management of head and neck tumors with multimodality therapy.

Open surgery remains the gold standard for the primary treatment of oral cavity, sinonasal, skull base, salivary gland and thyroid cancers, as well as sarcomas. Optimizing surgical education for both open and minimally invasive endoscopic and robotic techniques is fundamental for the future generation of head and neck surgeons and for the health of our patients. From a technical standpoint, head and neck surgeons will be needed to train in, embrace,

improve and extend our use of new technology—endoscopes, lasers, robotics, and image-guided surgery—in the operating room, with the aim of still improving functional results, as we are seeing with transoral resection for oropharyngeal tumors. The head and neck surgeon as an organ specialist will need to remain as the gatekeeper of patients and a leader of the multidisciplinary team for the initial diagnosis and staging and for patient selection for minimally invasive surgery, open surgery, or non-surgical organ preservation and for determining eligibility for inclusion in clinical trials [71]. Specialized follow-up of head and neck cancer patients in the clinic to enable early detection of treatable recurrences may be more sensitive and cost effective than routine CT and PET scans. Finally, specialized management of early and late toxicities can only be beneficial to patients from a quality of life perspective. The objective evaluation of functional results and a better understanding of the pathophysiology of treatment toxicities definitely need further study [72].

The epidemiology of head and neck tumors and our treatment approaches have been changing and may continue to evolve in the future. With aging populations in the West, we will have the opportunity to treat more and more elderly patients. Surgery may play a more important role in these patients, with less morbidity, in some cases, than chemoradiation, keeping in mind also that there seems to be no benefit of adding chemotherapy for the treatment of patients over 70 years old [73]. Economic issues will likely play a much larger role in the future as worldwide, countries grapple with increasing healthcare costs. Surgical treatment has been shown to be much less costly compared to radiation or chemoradiation, and reimbursement realities may dictate a greater surgical role [74].

Organ transplantation has become routine for many diseases and the number of organ transplant recipients is increasing, along with the risks of long-term immunosuppression-induced head and neck tumors and cutaneous squamous cell cancers in particular [75]. Finally, the challenge of entirely eliminating the morbidity of total laryngectomy with the implementation of laryngeal transplantation or a bio-engineered larynx may seem far away, but the future is rapidly advancing upon us [76–79] The number of composite tissue allotransplantations that have been performed for the face [80] and hands [81], which, like the larynx, can be considered as "non vital organs," have been increasing regularly. The use of mTOR inhibitors as immunosuppressive agents in laryngeal transplantation [82] but also for the treatment of various cancers is under study, and advances in immunosuppression and targeted therapies may soon make laryngeal transplantation for cancer a reality. However, restoring the complex function of the larynx will remain an additional challenge.

Conclusions

The past two decades have seen a declining use of open surgery as first-line treatment for patients with pharyngeal and laryngeal squamous cell carcinoma. Concurrently, however, there has been a continuing need for open surgery for patients with oral cavity cancers, sinonasal, skull base, thyroid and salivary gland cancers, and the rate of neck dissections has even increased in the past 6 years. The type of open surgery performed by head and neck surgeons has evolved to include more and more salvage surgery with more complex reconstruction involving free flaps, performed by high-volume surgeons in high-volume teaching hospitals. The future is bright for head and neck surgeons in multidisciplinary settings, developing and evaluating advances in technology and therapeutics and welcoming new paradigms that will appear in the next decades.

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