Robotic Surgery for Head and Neck Cancer

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Background

Following the introduction of the da Vinci® surgical robot (Intuitive Surgical®, Inc., Sunnyvale, CA, US) in 1997, the FDA gave its approval in 2000 [1]. It has since been used in a variety of surgical specialties, including general surgery, urology, cardiothoracic surgery and gynecology, facilitating conventional laparoscopic and thoracoscopic surgery.

Following a series of preclinical studies, the first live human application of robotic surgery in the head and neck for excision of base of tongue tumours was described in 2005 [2]. The acronym 'TORS' (TransOral Robotic Surgery) was thereby established in the medical literature, which has now been universally adopted.

Transoral Robotic Surgery (TORS)

TORS capitalised on the presence of the oral cavity as an access point for Natural Orifice Transluminal Endoscopic Surgery (NOTES), thus providing access to the pharynx, parapharyngeal space and larynx, without the morbidity of open surgery or the limitations associated with previously described transoral approaches, namely Transoral Laser Microsurgery (TLM).

Robotic technology overcomes the limitations of traditional endoscopic surgery. The dual channel endoscope offers a 3-D magnified view of the operative field, permitting depth perception compared to a 2-D view with conventional single-channel endoscopy. Moreover, wristed robotic instruments can operate with 7 degrees of freedom. This facilitates precise tissue manipulation within the confines of the oral cavity. Finally, surgical dexterity is enhanced by the tremor-filtering and motion-scaling features of the da Vinci® robotic system [3].

Oropharyngeal cancer constitutes the commonest application of TORS. It represents an increasingly common cancer affecting younger patients as a result of Human Papilloma Virus infection (primarily the HPV-16 genotype). This has been traditionally managed with 'organ preservation' treatments in an attempt to avoid the morbidity of open surgery. However, the toxicity and complications associated with primary chemoradiotherapy are often severe with substantial impact on both function and Quality of Life (QoL). TORS minimises the functional problems associated with chemoradiation through a de-escalation approach that is customised to the patient. This has created a paradigm shift in head and neck cancer treatment, and introduced the concept of 'functional organ preservation surgery' [4].

In just over a decade, TORS has evolved from proof-of-concept to standard-of-care in high volume robotic centres, with FDA approval for both benign and malignant diseases being given in 2009 [5]. Although indications for TORS initially involved base of tongue neoplasms, increasing clinical experience combined with preclinical studies on animals and cadavers, have rapidly expanded its applications [6].

Currently, TORS is a valuable treatment modality not only for tumours of the oropharynx, but also of the hypopharynx [7], parapharyngeal space [8] and larynx [9]. More recently, TORS has been used in managing carcinoma of unknown primary [10] and head and neck reconstruction, both in terms of free-flap positioning and microvascular anastomosis for the repair of large oropharyngeal defects following TORS resection [11].

There is an increasing body of evidence supporting the role of TORS in the treatment of a number of head and neck cancers. However, this mainly relates to case series and retrospective matched-cohort studies. There are 3 multicenter Randomised Controlled Trials (RCTs) currently under way: PATHOS, a UK-based study (HPV positive oropharyngeal cancer), the US RTOG 1221 (HPV negative oropharyngeal cancer), and finally the Canadian ORATOR study (early-stage oropharyngeal cancer).

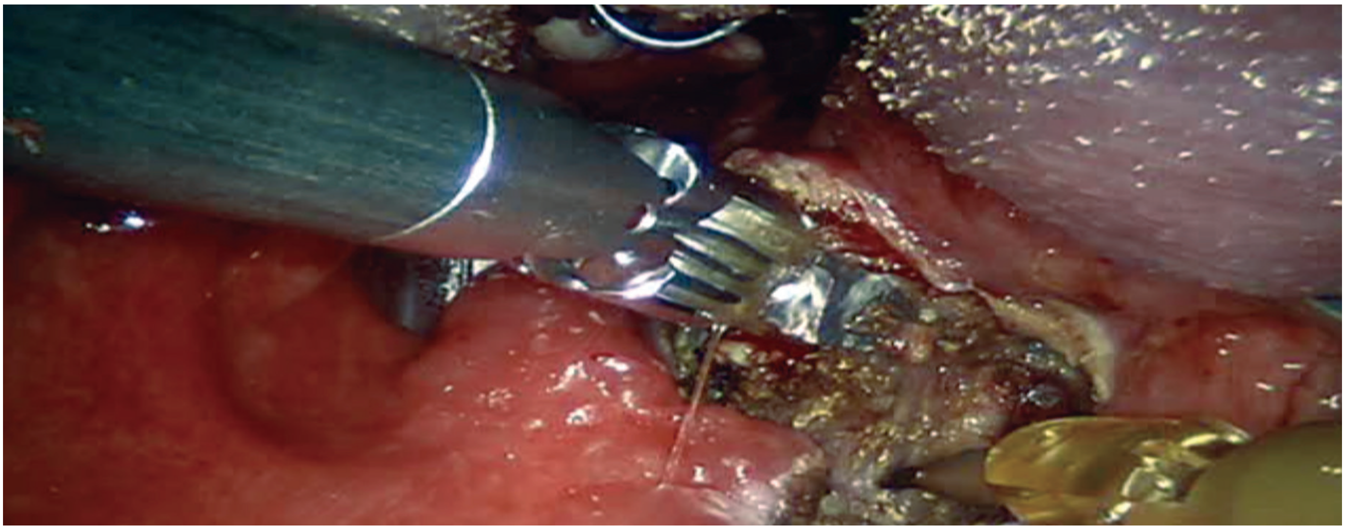
Transaxillary Robotic Surgery

Application of transaxillary robotic surgery for the treatment of thyroid cancer was first described in 2009 [12]. Following this, robotic thyroidectomy increased in popularity, with thousands of patients been treated for differentiated thyroid cancer (primarily of the papillary type) with excellent outcomes [13].

Both thyroidectomy (lobectomy, isthmusectomy, and/or total thyroidectomy) and concomitant neck dissection (central and/or lateral compartment including modified radical neck dissection) can be performed through the transaxillary route using the da Vinci® surgical robot with excellent functional and oncological outcomes [14].

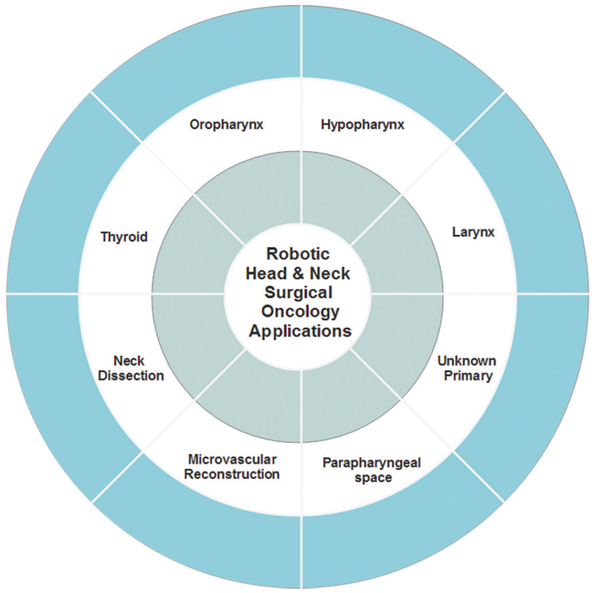
It is important, however, to recognise that most of the evidence supporting robotic thyroidectomy originates from South Korea where the majority of studies have taken place. Moreover, there are no RCTs on the subject. The uptake in the Western World has been particularly low, with robotic thyroidectomy accounting for <1% of total thyroid surgical volume in both the UK and US [15].

Several reasons have been implicated in this



TORS right oropharyngectomy

TORS supraglottic laryngectomy



discrepancy. These include cultural differences (negative connotation associated with horizontal neck scar in the Far East not present in Western societies) and anthropometric differences (patients from the Far East are on average smaller and thinner than their Western counterparts, facilitating transaxillary access). There are also differences in terms of the incidence and size of thyroid nodules on presentation (there is a national thyroid cancer screening programme in South Korea leading to nodules and thyroid malignancy being picked up at a higher rate and earlier stage) as well as incentives for surgeons (in the Korean healthcare system, remuneration for the robotic approach is double that of the endoscopic approach and quadruple that for open thyroidectomy, whereas in Western healthcare systems the route used for access has no impact on remuneration; instead, it is the extent of surgery that dictates reimbursement [15].

As a result, the evidence for robotic thyroidectomy (and/or neck dissection) in the treatment of benign and malignant disease should be interpreted with caution.

The Future

The da Vinci® surgical robot was not originally designed for head and neck surgery, as previously discussed. Thus there is room to develop a bespoke robot for transoral use.

The first step involves the design, manufacturing and trialing of miniaturized flexible robots, which will permit access to areas of the head and neck that are not currently possible (or limited) with existing robotic surgical techniques. Such areas include the glottic and sub-glottic larynx, trachea, nasopharynx, skull base (sellar and parasellar regions) and infratemporal fossa.

Moreover, robotic surgery could be combined with other existing technologies, like augmented reality or narrow-band imaging to enhance real-time intraoperative navigation, improving the precision of robotic resection and optimizing patient safety.

Another important factor that will determine the future of robotic head and neck surgical oncology is cost. This relates to the purchase, consumables and maintenance costs, which are currently prohibitive for most patients, insurers and healthcare systems. This is facilitated by the Intuitive Surgical® monopoly in the robotic surgery market. However, this will change as multinational medical device companies, such as Medtronic® (Minneapolis, MN, US), Medrobotics® (Raynham, MA, US), and the Johnson & Johnson® (New Brunswick, NJ, US)-Google® (Mountain View, CA, US) partnership, enter the robotic surgery arena. Market competition can be expected to drive down costs, making robotic surgical technology more widely available.

The results of several ongoing multicentre RCTs from both the UK and North America are awaited with interest in order to define the exact role and advantages of robotic surgical technology over 'established' treatments for head and neck cancer. TORS does have the potential to offer important advantages over both chemoradiotherapy (dose de-escalation or even as single modality therapy) and traditional open surgery (avoidance of incisions and minimising disruption of extrinsic pharyngeal muscles), but like with all surgical interventions, this holds true in carefully selected patients in the context of high-volume surgeons forming part of multidisciplinary teams within specialised centres.

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