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Review

Role of robotic surgery in oral and maxillofacial, and head and neck surgery

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Abstract

We review the current status of robotic surgery in the head and neck region and its role in oral and maxillofacial surgery.

Keywords: Robotic surgery; Transoral robotic surgery; Robotic thyroidectomy; Head and neck surgery; Robotic oral and maxillofacial surgery; Sleep apnoea syndrome

Introduction

The term "robot" derived from the Czech robota (slave labour) was introduced in 1921 by the playwright Karel Čapek in his satirical drama Rossum's Universal Robots[1] in which robots were created to do the banal work, while man was free to pursue more creative interests. Since this first fictionalised introduction, robotic technology has been widely developed. The idea of "robotic" or "telepresence" surgery was proposed by the National Aeronautics and Space Administration (NASA) in 1972 to provide remote surgical care to orbiting astronauts.[2] In surgery, the term "telepresence" refers to the remote operation of a robot to carry out surgical procedures (Figs. 1 and 2). Further development of robotic technology for surgery was driven in the 80s by the rapid growth of microinvasive surgery and the shortcomings of existing instruments. In 1995, using technology developed at SRI (Stanford Research Institute, CA), IBM (Yorktown Heights, NY), and MIT (Massachusetts Institute of Technology, Cambridge, MA), the Intuitive Surgical Corporation developed robotic arms and instruments with the number of degrees of freedom required for complex reconstructive surgery through a 1 cm incision.[2] Robot-assisted surgery has already been established successfully in various surgical specialties such as cardiac surgery, urology, and gynaecology.[3]

In head and neck surgery, minimally invasive approaches have been avoided because of concerns about visualisation, possible damage to vital structures, and the limited availability of effective instrumentation,[4] but efforts to reduce the trauma of such operations have recently led to the introduction of robot-assisted surgery.

This review presents currently published papers on the clinical application of robot-assisted techniques in head and neck, and oral and maxillofacial surgery (OMFS), and the reported benefits with regard to outcome and patient comfort. We evaluate the reported clinical applications, feasibility, and complications.

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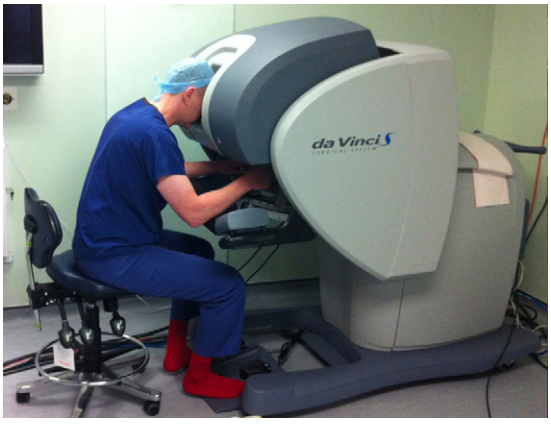

Fig. 1. The robotic console.

Method

We did a broad search in PubMed for papers with an available abstract in English or German using the terms "robotic", and "head and neck surgery". Publications related to the clinical performance of robot-assisted head and neck, and oral and maxillofacial surgery, were included, and preclinical studies and non-clinical review articles were excluded.

Results

In total 50 related articles (34 clinical, 16 preclinical) and 16 review articles were found, all published between 2005 and 2011. Of the 34 clinical publications, 22 were about transoral robotic surgery (TORS) for malignant or benign oropharyngeal lesions (11 case series with more than 10 patients, 11 case studies with less than 10 patients). The largest case series to use TORS included 148 patients.[5] Eleven case series or case reports presented robot-assisted thyroidectomy and we reviewed the six largest (more than 30 patients); the largest series included 1043 patients.[6] One case study reported robotic skull base surgery to the infratemporal fossa.[7]

Fig. 2. The sterile robotic operating field.

Transoral robotic surgery (TORS)

Case series with a minimum of 10 patients

Surgical resection with negative histological margins remains the oncological gold standard for head and neck mucosal squamous cell carcinoma (SCC).[8] Good visualisation and complete resection of the tumour with wide margins is essential for malignant lesions in the oropharyngeal region. TORS might be an alternative to existing open approaches (lip-split mandibulotomy) or endoscopic techniques in oral and maxillofacial oncology. We discuss the most recent publications that present the clinical application of TORS in head and neck, and oral and maxillofacial surgery.

Iseli et al. reported the use of TORS in 54 patients with histologically confirmed mucosal SCC of the upper aerodigestive tract with no known distant metastases. Robotic surgery was not used for patients with trismus (of less than 15 mm) or lesions that involved bony structures, or both. Most tumours in the oropharynx and larynx were T1 or T2 (Table 1 online).[18] Sixteen patients with low risk of a through-and-through defect had concurrent neck dissection, otherwise it was delayed for four weeks after the primary operation (6 patients). Adjuvant chemoradiotherapy was given where appropriate. The duration of hospital stay after TORS was only one (28%) or two nights (35%) (maximum one week in 6% of patients). Tracheostomy was reported to be indicated in only 9% of patients; otherwise the airway was protected postoperatively with short-term intubation (22%). No patient required tracheostomy beyond 14 days. The majority of patients (69%) could swallow adequately by the time of discharge and a few (15%) required a nasogastric feeding tube, which was removed after a maximum of two weeks. An enterogastric feeding tube remained in only 9 patients (17%), and was associated with factors such as preoperative need for a tube ($p = 0.017$), higher T-stage ($p = 0.043$), oropharyngeal or laryngeal tumour site ($p = 0.034$), recurrence, or a second primary tumour, or both ($p = 0.008$). Advanced age was reported to be important in addition to these factors.[9,10] Reported complications were a salivary fistula in one previously irradiated patient (6%) who had had concurrent neck dissection, and two patients (4%) had to have the margins resected again. Primary transoral robotic reconstruction may be beneficial as it reduces the rate of fistulas in patients who have TORS with concurrent neck dissection.[10,5]

Overall, low T-stage oropharyngeal tumours and edentulism seem to favour successful robotic resection.[9]

The feasibility of TORS for advanced oropharyngeal carcinoma (stages III and IV) was shown in 47 patients who had had staged neck dissection and adjuvant treatment. Disease-specific survival was 98% (45 of 46 patients) at one year, and 90% (27 of 30 patients) at two years. According to the pathological risk stratification 18 patients (38%) avoided the need for chemotherapy and five (11%) were not given