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ROBOTICS A HELPING HAND IN ORAL AND MAXILLOFACIAL SURGERY

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Abstract

Introduction: There is an ever-expanding drive to improve treatment outcomes. Robotics has contributed to a wide spectrum of enterprises, from vehicle assembling to space investigation with no exception to the field of medical sciences and its incessant drive for the enhancements of surgical procedure.

Objective: The objective of this article is to diagram the historical framework of robotics in oral and maxillofacial surgery, and detail the operating room procedures along with its outcome. Issues of cost-adequacy and patient worthiness will likewise be talked about.

Results and Conclusion: Robotics in oral and maxillofacial surgery has appeared to abbreviate hospital stays, decline entanglement rates and permit specialists to perform better with finer skills when contrasted with the conventional procedures. These advantages must be adjusted against expanded intraoperative times, huge money related expenses, and the expanded preparing trouble related with the training associated with robotics techniques. The results of such the cost-benefit evaluation seem to vary depending on the procedure being conducted. It is trusted that with the huge scope, randomized, imminent clinical preliminaries in progress, and an ever-growing examination base, a significant number of the exceptional inquiries encompassing robotics will be replied in near future.

Review criteria: We searched MEDLINE and Google Scholar using the terms ‘robotics in oral and maxillofacial ‘robotic surgery’, ‘robot-assisted surgery’, and ‘robotic-assisted surgery’ and manually searched references to identify papers in the English language.

Keywords: Robotic Surgery, Oral Maxillofacial Surgery, da Vinci Surgical System, Telesurgery.

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INTRODUCTION

Robotic-assisted surgery has revolutionized minimally invasive surgery in multiple surgical specialties for more than three decades. Robot-assisted surgery is currently utilized in almost every surgical specialties. In general surgery, there is an abundance of reports on its use in cholecystectomy, Heller myotomy, Nissen fundoplication, bowel resection with anastomosis, splenectomy, and Whipple and hepatobiliary surgery.[1]Currently, robotic-assisted surgery has a wide range of applications in otorhinolaryngology. These include skull base surgery, tumour removal from the upper aerodigestive tract, and transoral surgery for sleep disorders. In addition, various approaches have been utilized for neck surgery, i.e., the trans axillary approach for thyroid and parathyroid surgery and the retro auricular approach for neck dissection, congenital lesion resection, and salivary gland surgery.

The incorporation of robotic-assistedhead and neck surgery canbeattributed to the improvement in visualization and instrumentation through technological advancements, a faster learning curve, and exploring organ conservation treatment protocols for a better understanding of head and neck cancer biology.[2]

This review examines the history of robotic surgery, the benefits of this technology, and its use in different head and neck surgical procedures, followed by a discussion of cost-effectiveness and patient acceptability.

A BRIEF HISTORY OF ROBOTIC SURGERY

The PUMA 560, the first robotic surgery system, was designed in 1985 to improve the accuracy of image-guided intracranial biopsies. Further refinement in the early 1990s led to ROBODOC, which was the first robotic system to receive FDA approval for arthroscopic hip surgery in 1994.[3]In response to interest in medical ro bots, The National Aeronautics and Space Administration (NASA) and Stanford Research Institute (SRI) worked together to develop telepresence surgery, which involves virtually placing a surgeon from distant locations into the operating theatre, in the early 1980s. Experience with minimally invasive laparoscopic procedures has helped surgeons understand the limitations of rigid equipment and two-dimensional views. This has resulted in the development of semi-rigid robotic equipment with three-dimensional views for the operative setting. Combining these tools with telepresence surgery guided to the development of the Automated Endoscopic System for Optimal Positioning (AESOP), a robotic arm (regulated by a surgeon’s voice commands) that manipulates an endoscopic camera.[4] Intuitive Systems (Sunnyvale, CA) released the SRI Telepresence Surgery System that was recently updated to the current da Vinci Surgical System, the most common robotic system in use today.[5]

The da Vinci Surgical System

The da Vinci Surgical System works as a traditional master-slave plan with the surgical robotic cart containing numerous control arms that are worked remotely from a reassure. The robot contains video-assisted demonstration and PC enhancement and is made out of three segments: the surgical cart, the vision cart, and the surgeon's console (Figure 1). The surgical cart (or slave unit) is furnished with four arms; one arm holds a 0◦ or 30◦ 12 mm stereoscopic camera (with 2 optical channels, every 5 mm), and the other three arms hold 5 mm (pediatric size) or 8 mm (regular) EndoWrist instruments (Intuitive Surgical Inc.), that are effectively exchangeable by assistant staff as per the surgeon's need and technique prerequisite. The vision cart is furnished with two light sources, an insufflator, and equipment that produces the three-dimensional picture. The cart for the most part holds another screen for the associate specialist. The specialist's support (or ace unit) shows two pictures, one for each eye. This makes a 3-dimensional picture that incredibly improves profundity observation inside the surgical field. Also, the reassure is the interface for the surgeon to control the instrument, by controlling the hand controllers. The surgeons reassure is outfitted with pedals to control the camera and instrument arm grasping (withdrawal of the hand controllers from the careful arms) camera controller, center change, and electrocautery. There are likewise surgeon personalization and settings controls. The EndoWrist instruments are constrained by the surgeon at the ace comfort and give different degrees of freedom, including pitch, yaw, and roll, in addition to two extra degrees of freedom in the wrist and two others for apparatus activation. The sum of seven degrees of freedom is present in contrast with endoscopic instruments that have only 4 degrees.

Robotics in oral and maxillofacial surgery

In 2001 M. Klein et al conducted a study in which cutaneously approved robots were used to surgically insert craniomandibular implants that anchored silicone ear prosthesis onto the skull. Here the robot worked on interaction with the surgeon. The robot navigated the surgeon intraoperatively to plan implant positions and also guided the insertion procedure. A total of 30 implants in 13 patients, were inserted with no intraoperative injuries. An absolute implant position accuracy of about ± 1 mm and a relative accuracy between the implants of about ± 0.2 mm was reached. This accuracy enabled the immediate application of the preoperatively manufactured ear prosthesis following surgery. The rehabilitation time for the patient was also very shortened.[6] Go miyanothom e. Lobe et al 2007 compared total thyroidectomy using a robotic-assisted bilateral trans axillary endoscopic approach (r-baea) and a non–robotic-assisted bilateral trans axillary endoscopic approach (baea) to assess its safety and feasibility in 9 patients where 8 patients were female and 1 was male suffering from graves' disease, Two r-baeas and 7 baeas were performed. The mean operating time was 385 minutes for r-baea and 259 minutes for baea. Resectioned specimens had a median diameter of 5.9 cm; the mean intraoperative blood loss was 15.0 ml. In all cases, recurrent laryngeal nerve and parathyroid glands were detected and preserved intact. No patients required a conventional approach but there was one instance of postoperative wound erythema, and 2 patients experienced hypocalcemia that resolved spontaneously. Two patients with large glands experienced transient postoperative hoarseness. The mean total postoperative morphine dose administered in the first 24 hours was 1.5 mg. postoperative pain was minimal, and all patients were satisfied with the cosmetic. Except for one patient all were discharged the day after surgery and returned immediately to normal activities. This study concluded that total thyroidectomy using baea with or without robotic assistance is feasible and safe with the advantage of minimum or no cervical scar, no significant morbidity, less postoperative pain following surgery and early return to normal activity compared with other published techniques.[7]Tima.Iseli et al in 2009 evaluated functional outcomes following TORS for head and neck cancer in one and half years where 54 out of 62 candidate patients underwent transoral robotic tumor resection. Tumors were most commonly oropharynx (61%) or larynx (22%) and t1 (35%) or t2 (44%). The majority of them underwent chemotherapy (31%) and radiotherapy (22% preoperative, 41% postoperative). Tracheostomy was used less frequently

(9%), and endotracheal intubation (22%), all of which were decannulated after 14 days. Most of the patients started oral intake prior to discharge (69%) or within two weeks (83%). A worse postoperative dysphagia record score was associated with a retained feeding tube. At a mean 12 months follow-up,17% of the patient retained a feeding tube. Complications including airway edema (9%), aspiration (6%), bleeding (6%), and salivary fistula (2%) were managed without major sequelae.[8]In 2010,Hilliary N .Whitereported 2-year survival outcomes for the head and neck squamous cell carcinoma using transoral robotic-assistedresection. In this prospective case study89 patients with head and neck squamous cell carcinoma of all stages and subsites, underwent transoral robotic-assisted resection with a median follow-up time of 26 months. The main outcome measures weredisease-free survival, cancer recurrence, and gastrostomy tube dependence 71 patients had T1 or T2 tumors while 18 patients had T3 or T4 tumors. There were 24 patients with overall stage I or II disease and 65 with stage III or IV disease. At the time of the last follow-up visit,there had been a total of 11 patients with recurrent cancer 3 with local; 7 regionals (2 of whom also had distant metastases); and 1, distant. 7 patients were treated for recurrent disease.82 patients had no evidence of disease, 1 patient died of the disease, 2 died of another disease, and 4 were alive with the disease at the last follow-up visit. Results of Kaplan-Meier survival analysis showed, 86.5% recurrence-free survival rate for the cohort. None of the patients wasgastrostomy tube dependent at the last follow-up visit.[9]Brian Hung-hinlang et al in 2010, compared surgical outcomes between endoscopic and robotically assisted thyroidectomy. The RAT (robotically assisted thyroidectomy) uses the same endoscopic route as the GTET (gasless, trans axillary endoscopic thyroidectomy) but with the assistance of the robotic system. 46 patients underwent endoscopic thyroidectomy, 39patients had GTET and 7 had RAT. All the patients were followed up for at least 6 months after surgery the median total procedure time was significantly longer for RAT than for GTET but the contralateral recurrent laryngeal nerve was more likely to identified in RAT and GTAT needed one more surgical assistant.Blood loss, hospital stay, and surgical complications were similar in the both groups.Pain score on postoperative day was significantly higher on day 0 and day 1 in RAT. In early experience, RAT had prolonged total procedure time and resulted in a higher pain score on day 0 but eliminated the need for any surgical assistant at the time of the operation.[10]Marc.A.Cohen in 2010assessed hpv related outcomes after TORS with adjuvant therapy as indicated.This study consisted of a retrospective review of 50 patients with oropharyngeal with squamous cell carcinoma within a prospective single-arm cohort study in whichHPV status, margin status, relapse pattern and survival were been used as outcome measures. At the end of the study 37 patients were HPV-positive with 34 patients being serotype-16. In 92.3% (HPV-negative) and 94.6% (HPV-positive)negative margins were achieved. In the HPV-negative group, there were no local recurrences whereas 1 patient had both regional and distant recurrence. In the HPV-positive group, there were no local or regional recurrences and 2 patients had distant recurrences. There were no statistically significant differences in survival between the 2 cohorts. This study concluded that tors as a primary surgical modality, followed by adjuvant therapy as indicated, offers disease control in both HPV-negative and HPV-positive groups.[11]Claudio Viciniet al in 2010 evaluated the feasibility, tolerability, and efficacy of tongue base management by means of TORS in patients suffering from obstructive sleep apnea-hypopnea syndrome (OSAHS) primarily related to hypertrophy of the tongue base.17 patientswere operated with a follow-up of 3 months were evaluated. The postoperative polysomnographic results were fairlygood and the functional results were very encouraging and complications were rare and of minor importance.[12]Jeremy Richmon et al in 2010 studied the effect of TORS on short-term outcomes and cost of care after oropharyngeal cancer surgery. In this retrospective cross-sectional study analysis of 9,601 patients who underwent an extirpative procedure for a malignant oropharyngeal neoplasm in 1 year was performed using discharge data from the nationwide inpatient sample. TORS was performed in 116 cases. When compared to patients receiving non-tors procedures, tors patients had a decreased rate of gastrostomy tube placement, tracheotomy tube placement, and nonroutine discharge. After controlling for all other variables, including comorbidity, the extent of surgery, and teaching hospital status, tors was associated with significantly decreased length of hospitalizationand hospital-related costs.[13]David j. Terris et al in 2011 performed 18 robotic facelift thyroidectomy (RFT) procedures in 14 patients which there were 13 females and 1 male, with an age range of 12–70. The procedures included 13 lobectomies, 1 bilateral thyroidectomy, and 3 completion thyroidectomies. The first procedure was performed on an outpatient basis without the use of a drain. There were no conversions to open surgery, no permanent nerve injuries, and no cases of hypoparathyroidism. The operating times were 97 to 193 minutes. Thus, the study concluded that rft is a feasible remote-access thyroidectomy approach. With their initial experience, it is stated that it may be performed in a safe and reproducible manner without a drain and on an outpatient basis.[14]Young min park,won shikkim et al in 2012 conducted a study in order to determine whether TORS was suitable as a minimally invasive treatment for oropharyngeal cancer. In the period of 2 years, 39 patients with oropharyngeal cancer were treated by TORS where 37 patients (95%) had histologically clear margins of resection. Overall survival at 2 years was 96% and disease-free survival 92%.No serious swallowing difficulties were seen on the videopharyngogram. Foss scores of 0 to 2 were achieved by 36 out of 38 patients (97%) with good swallowing; one patient had poor score but was able to have an oral diet following postural training. The acoustic waveform analysis showed that voices were kept relatively within the usual range. The oncological and functional results of TORS were quite acceptable for the treatment of oropharyngeal cancer.[15]Ho-sheng lin et al in 2013 evaluated the efficacy of base of tongue (BOT) resection via TORS in the treatment of OSAHS. Inthis case series of 2 years studies,BOT resection via TORS was performed on 12 patients who underwent BOTresection alone were included in this study. The mean apnea-hypopnea index (AH-i) was recorded preoperatively and postoperatively. The difference in AH-i was statistically significant and reflected an average AH-i reduction. Statistical significant reductions in daytime somnolence level, as measured by Epworth sleepiness scale, and snoring intensity, as reported by a bed partner using a visual analog scale wereachieved. There was no statistically significant difference between the preoperative and postoperative body mass indexor minimum oxygen saturation.[16]Thomas k. Chung et al in 2014 compared the clinical and cost outcomes of TORS versus open procedures in this retrospective analysis of 2 years.Tors represented 2.1% in 1st year and 2.2% in 2nd year of all transoral ablative procedures. Patients undergoing open partial phrenectomy for oropharyngeal neoplasmshad more severe illness compared to TORS however, after controlling for minor-to-moderate severity of illness,open partial pharyngectomy was

associated with a longer hospital stay,higher charge, higher cost, higher rates of tracheostomy and gastrostomy tube placement,and more wound and bleeding complications. TORS was associated with a higher rate of dysphagia.When compared to open patients with the same severity of illness, the lower cost of tors was still significant in the major-to-extreme severity of illness group but was associated with higher complication
rates. According to a similar analysis of T ORS partial glossectomy for base tongue t umours, TORS partial glossectomy for anterior tongue tumours revealed prolonged hospital stays and no benefit in charge or expense compared to open surgery. Early results from this study show that partial pharyngectomy and partial glossectomy for the base of the tongue gives clinical and cost savings for patients, but that partial glossectomy for the anterior tongue has no such advantages. It is likely that anatomic accessibility and the extent of surgery factor into the effectiveness of TORS.[17]For the treatment of advanced-stage oropharyngeal carcinomas, Vincent l. Biron,daniel a O'connell et al. in 2017 compared the lip-splitting mandibulotomy method versus tors.. A study was done on 18 patients with advanced-stage OPSCC who received TORS with radial forearm free flap reconstruction (RFFF)to a matched cohort of 39 patients who received a lip-splittingmandibulotomy and RFFF. Patients were matched for stage, age, and gender as well as p16 positivity and smoking, Length of hospital stay,tracheostomy decannulation time,operative time, surgical margin status, and postoperative complications were compared between groups. Patients who received TORS with RFFF had a significantly lower mean length of hospital stay and also there were no significant differences seen between groups in terms of operative time, tracheostomy decannulation time, margin positivity and post-operative complications thus this study concluded tors with radial forearm free flap reconstruction is a safe, effective and cost-saving alternative to the lip-splitting mandibulotomy approach for the treatment of advanced stage OPSCC.[18]David.w.Schoppy et al in 2017 presented the largest review to date of patients with minor salivary gland tumors of the oropharynx managed with transoral endoscopic head and neck surgery (eHNS) as primary or salvage therapy. A retrospective study was conducted which includes data from 20 patients with minor salivary gland tumors of the oropharynx managed. Details of tumor pathology, margin analysis, adjuvant therapy, and an assessment of oncologic outcome were includedthe base of the tongue which was the most common tumor site (75%),adenoid cystic carcinoma (acc) (35%), and negative margins were obtained in most (95%) through an endoscopic-only procedures. Overall, 50% of patients received postoperative radiation therapy. Postoperative complications were limited, with one patient (5%) returning to the or for control of post-operative oropharyngeal bleeding. On average follow-up of 36 months, 90% of patients were alive with no evidence of recurrence. In this experience, transoralehns provided a safe and consistent surgical approach to the management of minor salivary gland malignancies, with low complication rates and good locoregional control.[19]P.Capaccio et al in 2019 proposed the conservative transoral approach to hilo-parenchymal submandibular stonesas an alternative to traditional sialoadenectomy’s main purpose was to preserve the gland and minimize the risk of cervical scar and damage to the marginal mandibular branch of the facial nerve. Two patients, each with a 15 millimetre and an 8 millimetrehilo-parenchymal submandibular stone, underwent transoral robotic surgery with the Si Da Vinci surgical robot to remove the stones. The procedure was performed

successfully and tolerated well, with a 1-day hospitalization. There were no complications such as lingual nerve paresthesia, gland swelling, pain, infection, or ranula. The patients were followed up clinically and ultrasonographically for the first 3 months to verify symptom relief and persistence of stones; no symptoms or stones were found.[20]

Costs of robotic surgery

The cost-effectiveness of robotic surgery is assessed by balancing the potential benefits, such as reduction in hospital stay and reduction in complication rates, with the costs, which include the need for added surgical training,the equipment cost, its maintenance and repair,and increased operating room setup time. Robot-assisted surgery has been reported favorably in oral and maxillofacial surgery. Nevertheless, the cost benefit of robotic surgery varies depending on the treatment and is not always present. For example, robot-assistedtrans axillary thyroidectomy compared with the traditional cervical approach showed no difference in rates of temporary hoarseness, bleeding, infection, seroma, numbness,and length of hospital stay. Additionally, establishing a robotic surgical unit can cost ranging between $1 million to $2.5 million.[21] Maintenance costs are $138,000 per annum reported in the literature. Even ifrobotic surgery is said to be cost-effective, such initial costs are high-priced for many centers. In addition to this, many surgeons are inexperienced in robotic surgical techniques and there islimited number of centers with the necessary systems for training and also there are reduced surgical training opportunities. It is difficult to assess the accurate cost-effectiveness of robotic surgeryas very few studies based on cost-effectivenessareadvocated in the literature. Also,there is a lack of long-termfollow-up which makes assessment of long-term cost-effectiveness problematic.In the future, it is hoped that increased industry rivalry and a rise in specialized robotic centres will boost robotic surgery's cost-effectiveness.

CONCLUSION

In conclusion, robotic surgery had started a new era of telesurgery. The present outlook of this refined technologyfor the least invasive method has captured the surgeon’s expedition.As per the primary results, from the patient’s perception as well, its regular use in the near future is unavoidable. The Oral and Maxillofacial surgical procedures are multifaceted and have potentially significant immediate postoperative morbidity and risk of mortality thatis why it is important that patients are well-evaluated and planned carefully. The latest robotic system, da Vinci robot is an excellent surgical tool in oral and maxillofacial surgery and provides excellent visual access, tremor-free instrumentation, and easy access for an assistant surgeon. Thus, surgery canbeperformed safely, efficiently, and with ease. Besides many of the benefits, they are not being used in routine surgery as each patient is an individual and in each surgery, some unexpected situations can happen, for which robots cannot be pre-programmed, so total automation is not desired or possible, and surgical robots will always work in cooperation with the surgeon and cannot substitute them. Furthermore, so far there is no general standard of safety recommendation for medical robot devices either. They must be more suited to the operating room, smaller, and more portable. Another problem is preoperative planning, which takes much time and is not desired in routine clinical work. Therefore, new concepts for computer-assisted surgeries rely on intraoperative planning. One of the main challenges is still the interdisciplinary work of engineers and surgeons, which have to find a common language.

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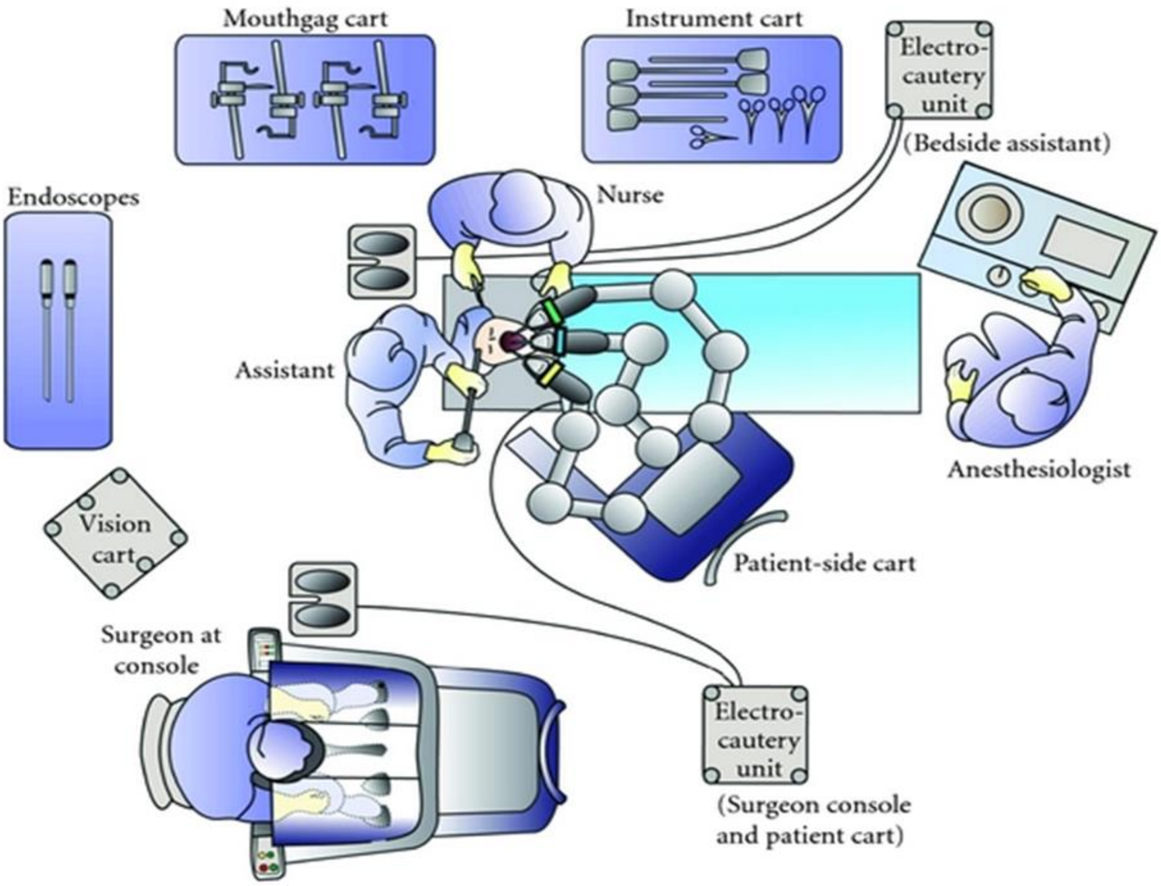

Figure No 1: Operation room setup (Courtesy of Intuitive Surgical Inc., 2010)