TRANSORAL ROBOTIC SURGERY (TORS)

ESSAY

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بسم الله الرحمن الرحيم

قَالُوا سُبْحَانَكَ لاَ عِلْمَ لَنَا إِلاَّ مَا عَلَّمْتَنَا إِنَّكَ أَنتَ الْعَلِيمُ الْحَكِيمُ

صدق الله العظيم

سورة البقرة آية (٣٢)

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List of abbreviations

Abbreviations	Meaning
TORS	Transoral robotic surgery
RS	Robotic surgery
٣-D	٣-dimensional
NASA	National Aeronautics and Space Administration
SRI	Stanford Research Institute
MIS	Minimally Invasive Surgeries
DAR-PA	Defense Advanced Research Projects Administration
FDA	Food and Drug Administration
ENT	Specialty of ear, nose, and throat
CO٢ LWG	Carbon dioxide laser wave guide
HD	High definition
TLO	Transoral lateral oropharyngectomy
BOT	Base of tongue
SCC	Squamous cell carcinoma
OSCC	Oropharyngeal squamous cell carcinoma
RALT	Robotic assisted lingual tonsillectomy
SLG	sublingual gland
LN	Lingual nerve
PDT	Photodynamic therapy
PPS	Parapharyngeal space

TORS- TL	Transoral robotic surgery- total laryngectomy
DOF	Degree of freedom

INTRODUCTION

The term “robot”, derived from the Czech robota (slave labor), was introduced in ١٩٢١ by the play writer Karel Cˇapek in his satirical drama Rossum’s Universal Robots in which robots were created to do the banal work, while man was free to pursue more creative interests. Since this first fictionalized introduction, robotic technology has been widely developed (Borumandi et al, ٢٠٠٤).

Surgical robots emerged after the development of automated robotic arms for industrial and aerospace applications. Adaptation and miniaturization of commercial robotic technology has facilitated its introduction into clinical medicine. The miniaturization of both the mechanical robotic components and the solid-state components has allowed these miniaturized robotic arms to work within the human body. By coupling the robotic instruments with improved ٣-dimensional (٣-D) optic technology, surgeons have the advantages of precise instrument movement and virtual immersion into the surgical field (Hockstein and O'Malley, ٢٠٠٨).

The interest by ENT surgeons to evaluate the real potential of robotic surgery (RS) in their field should not startle. Nonetheless, RS was introduced only recently in the field of ENT,

mainly because most robots were initially developed for abdominal/thoracic surgery. The initial primary obstacle to the performance of robotic assisted pharyngeal and laryngeal surgery were the means of introducing the relatively large robotic arms and instruments into the narrow funnel created by the oral cavity, pharynx, and larynx, and the means of suspending and exposing the laryngopharynx to allow for adequate exposure without interfering with introduction of the robotic arms, in addition to the ability to achieve hemostasis (Hockstein and O'Malley, ٢٠٠٨).

AIM OF THE WORK

The aim of this review was to assess the clinical application of robot-assisted techniques through transoral approach and the reported benefits with regard to outcome, feasibility, advantages and disadvantages.

History of robotic surgery

The transition from science fiction to reality occurred in 1958 when General Motors introduced the Unimate to assist in automobile production (Hockstein et al, 2007).

National Aeronautics and Space Administration (NASA) in 1972 proposed to develop a method to provide surgical care to orbiting astronauts. In late 1980s, researchers at Stanford Research Institute (SRI) began to look for ways to enhance skills of surgeons in Minimally Invasive Surgeries (MIS) and manufactured an SRI system. Motivated by early success of this system Defense Advanced Research Projects Administration (DAR- PA) planned to expand this concept to develop telesurgery to enable surgeons to perform life-saving surgeries on wounded soldiers. MIS techniques came into vogue in the late 1980s. Surgeons were no longer required to place their hands within the body of patients. The instruments in our hand were traded off with long manipulators with less degree of freedom. This whole phenomenon resulted in loss of wrist articulation, feedback control, fulcrum effect and two-dimensional vision. Robotic surgery promises to eliminate many of these drawbacks (Garg et al, 2010).

In 1985, the first surgical application of industrial robotic technology was described when an industrial robotic arm was modified to perform a stereotactic brain biopsy (Hockstein et al, 2007).

Further development of robotic technology for surgery was driven in the 80s by the rapid growth of microinvasive surgery and the short comings of existing instruments (Bouromandi et al, 2011).

The da Vinci robot (Figure:1) was approved by the US Food and Drug Administration (FDA) for use in general surgery in 1997 and is currently undergoing studies for use within the specialty of ear, nose, and throat (ENT) (Goh et al, 2010).

Fig. 1: Da Vinci surgical system (Arora et al, 2011)

- In Otolaryngology

The use of surgical robots in otorhinolaryngology did not start until 2003, when this technique was first studied in animal models along with cadaveric studies (Goh et al, 2010).

The first ENT procedure (excision of vallecular cyst) was performed and successfully completed in 2005, and it was reported by McLeod and Melder (Orvieto et al, 2011; Garg et al, 2010).

In the same year 2005, the ENT robotic surgery was done by Weinstein successively on animals, cadavers, and then in clinical practice initially on oropharyngeal tumors (Arora et al, 2011; Aubry et al, 2011).

Hockstein et al. in 2005, reported technical feasibility of operating with the three arms of the da Vinci Surgical Robot through a mouth gag for airway surgery on a mannequin and cadavers. Success with cadaveric robotic surgery has translated into clinical experimentation such as transoral robotic sugery (TORS) supraglottic partial laryngectomy and base of tongue neoplasm resection (Garg et al, 2010).

O'Malley et al. performed the first transoral surgical procedure in 2006. All three patients had tongue base malignant tumors removed. Patients developed no complications and negative margins were confirmed in all cases (O'Malley et al, 2006; Orvieto et al, 2011).

In 2007, Solares and Strome described transoral carbon dioxide laser robotic-assisted supraglottic laryngectomy in a 74-year-old woman with a large supraglottic tumor. In the same year, Weinstein described robot-assisted supraglottic partial laryngectomy and radical tonsillectomy (Goh et al, 2010).

The team of the Institutional Review Board of Yonsei University (Korea) in 2008 described a modified lateral oropharyngectomy for a tonsillar cancer. The technique for transoral surgical removal of tonsillar tumors has been described by Holsinger (2005) and Weinstein (2007) (Moore et al, 2012).

Transoral robotic surgery using a new CO2 laser wave guide (CO2 LWG) was applied for malignant pharyngolaryngeal tumors in 2010 (Remacle et al, 2011).

- The da Vinci Surgical Robot

Da Vinci designed the first sophisticated robotic arm in 1495 with four degrees of freedom and an analog on board controller supplying power and programmability. Von kemplen's chess playing automaton left arm was quite sophisticated. Unimate introduced the first industrial robotic arm in 1961, it has subsequently evolved into the PUMA arm. In 1963 the Rancho arm was designed; Minsky's Tentacle arm appeared in 1968, Scheinman's Stanford arm in 1969, and MIT's Silver arm in 1974. Aird became the first cyborg human with a robotic arm in 1993. In 2000 Miguel Nicolalis redefined possible man machine capacity in his work on cerebral implantation in owl-monkeys directly interfacing with robotic arms both locally and at a distance. The robotic arm is the end effector of robotic systems and currently is the hallmark feature of the da Vinci surgical system making its entrance into surgical application (Moran, 2007).

- The modern design

In the 90s, there were three main systems: da Vinci system by Intuitive Surgicals, Computer Motion system by

Aescop and the Zeus Robotic System. However since then, Computer Motion system was bought over by Intuitive Surgicals and today only the da Vinci system is being actively marketed as a surgical robot. Surgical robots can be classified into active, semi-active or passive based on the extent of their participation in the surgery. Active robot: is programmed to perform an entire procedure and does not require any input from the surgeon. Semi-active robot: requires input from the surgeon to carry out power directed activity. Passive robot: is completely controlled by the surgeon (Garg et al, 2010).

The da Vinci is available in four different models: standard, streamlined (S), S-high definition (HD), and S integrated (i)-HD. Each system has three components: surgeon console, patient cart, and vision cart. There are several sterile accessories and Endowrist instrument required for each system. The standard system was released in 1999 and was originally offered with one camera arm and two instrument arms. Later a third instrument arm became available as an option on new systems or an upgrade to existing systems (Higuchi and Gettman, 2011).