Application of Robotics in Oral & Maxillofacial Surgery: Literature Review

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Abstract:

Robots are being used in various fields since decades but their use in the field of medicine and surgery has been very limited. With the introduction of robots in the field of surgery, the procedures that were once associated with morbidity can be done with less blood loss and minimal complications. The previous literatures have mentioned the advantages and disadvantages of using robotics if field of surgery.

The current literature review includes the studies on the use of robotics in the various fields of surgery, published between 1988 and 2017. This review study is focused on the use of robotics in field of oral and maxillofacial surgery including the applications of robotics in various procedures, their advantages and disadvantages.

The results of this literature review suggested that there are several advantages of using robotics in oral and maxillofacial surgery mainly in terms of precision of surgical procedures, reduced man power and duration of the surgery, reduced hospital stay and complications. High installation charges being the major disadvantage has been the reason of limited use of robotics in oral and maxillofacial surgery.

Keywords: Transoral Robotic Surgery, TORS, daVinci, RobaCKa, Robotic Surgery

Introduction:

Robot: "A mechanical device that can be programmed to carry out instructions and perform complicated tasks usually done by people". (**World English Dictionary)**[1]

A robot is a powered device that is computer-controlled manipulator and has artificial sensing. This can be reprogrammed in order to move and position the tools so that a wide range of functions can be carried out. [2]

The term "robot" was derived in 1921 from *Czech robota* which meant slave labour and was introduced by the playwright *Karel Capek*. He introduced them in satirical drama 'Rossum's Universal Robots'. In this drama, the robots were created to do the banal work, whereas man was free to carry out more creative works. The robotic technology has become widely developed after this first fictionalized introduction of robots by *Karel Capek*. [3]

Later, in 1938, the term "robotics" was first coined by *Isaac Asimov*. He coined it in one of the short stories "Runaround" that was published in the magazine named 'super science stories'. This was followed by the stories where the robots were shown to have conflicts with the human masters. This collection was published in the year 1942 under the title 'I Robot'. 3 laws for the robot behavior were described by him: [1]

i. A robot may not cause any harm to humans or through inaction allow to come to harm.

ii. A robot should follow the orders that are given to it by the humans except in cases where doing so will conflict with the 1st law.

iii. Robot should take care and protect and its own existence. It should be done as long as the 1st and the 2nd laws are not conflicted.

Kwoh et al, in 1985, introduced the first surgical robot. Since then, their development in order to provide more accuracy and efficiency during surgeries has been slow but steady. According to *O, Malley* and *Weinstein et al, Transoral Robotic Surgery (TORS)* have a potential for the management of tumors of upper aerodigestive tract. Further, they have stated that their use in humans is also safe.[4]

In the year 2005, there was a surgical technique that was reported in canines and cadaveric models. This was later termed as *Transoral Robotic Surgery* (TORS). This *TORS* technique was used for resection of tongue base in three patients in 2006. The main advantage of using this technique was reported as improved vision of the cranial nerves IX and XII, lingual nerves and arteries. [5]

Procedures that were once associated with morbidity, are now being performed with reduced levels of blood loss and fewer complications than the conventional open techniques. Also, the intra-operative time, stays for intensive care and duration of hospitalization has been reduced. All these have been seen after the introduction of robotics in the field of surgery. [6]

In Oral and Craniomaxillofacial surgery the robotic devices are used for drilling of holes, for milling of the bone surfaces in field of plastic surgery, for performing osteotomies, for drilling of bed for implants, for pre-operative automatic selection of osteosynthesis plates; for bending of these plates according to the surface they are being applied and for their placement during the intra-operative procedures. [7]

Transoral Robotic Surgery (TORS) can also be used in management of cases such as radical tonsillectomy. It provides an excellent access to resect the carcinomas present in the tonsil with acceptable acute morbidities. [8]

Recently, the investigators have worked for the role of *TORS* in management of head and neck tumors. According to the works conducted by them, *TORS* is safe and has a potential to be useful for managing the carcinoma of base of tongue and supraglottic region. [4]

Currently, the *daVinci* robot is the only FDA approved surgical robotic system that is available for surgeries in the head and neck region.[5]

Material and Methods:

An online search of the databases for studies related to use of robotics in Oral and Maxillofacial Surgery between 1988 to 2017 was done and studies including the uses, advantages and disadvantages of using robotics in field of surgery were selected.

Discussion:

Transoral robotic surgery (TORS), is a minimally invasive method. It is useful to provide a more precise surgery with lower morbidity. The reason for same is that it is caried out through the oral cavity and the extraoral incision is not required.[9]

<u>Robotic Devices in Oral and Maxillofacial Surgery</u>:

In field of oral and maxillofacial surgery, the robots find their use while milling the surface of the bone, drilling holes, making osteotomy cuts, selecting the plates and bending them for adaptation on the surface to be applied and while planning for orthognathic surgeries. Tongue based adenoid carcinomas are also being treated with robotic technique/*TORS* (Transoral Robotic Surgery). Another indication for the application of surgeries assisted by robots/*TORS* in field of maxillofacial surgery are the open and aggressive surgeries which can produce adverse effects on speech and swallowing. [10]

Weihe et al in 2000, did the initial work in craniofacial domain by evaluating the practicability of intra-operative instrumentation using the navigation system and robotics for reconstruction of fronto-temporal bone resection in a single step using computer aided facilities. From this they concluded that resection done with the help of template proved to provide more precision and practicability.[11]

In 2002, *Terris et al* used the procine models to carry out the endo-robotic surgery and found it to provide improved precision and efficiency for problems associated in neck region. They also reported advantages such as 3-D imaging, flexibility, versality, precision and coordinated procedures. According to them the complications associated with cervical endoscopy such as emphysema and pneumothorax were overcome with the introduction of endo-robotic surgery.[12]

In the same year, in 2002, another robot was assessed by *Engle et al.* This was called *RobaCKa*, and was developed by IPR University. It was assessed for accuracy in milling in field of craniofacial surgeries that were associated with the vital structures. They found that there was an accuracy of 1.0mm starting from planning to the execution of the procedure. Optical navigation system was used to counteract the micromovements of the patients. [13]

In 2003, *Tamer Theodossy et al* carried out a study on orthognathic procedures where surgeries on 21 patients performed manually were compared with the model surgeries performed by the robots. In their study they observed the surgeries that were performed using the robotic arms provided more accuracy and precision in the antero-posterior and the vertical planes as compared to those performed manually. [14]

Robotic system to place dental implants were first introduced by *Auranuch et al* in 2009. Based on the homogenous transformation algorithms, they developed the dental implant surgical navigation system. The anatomy was assessed first by making use of CT and the computer aided surgery system. After that 3D images with real time monitoring were assessed intra-operatively. Implants were placed with a deviation of less than 1.0mm and the mean error of the navigation system was found out to be 0.35mm.[15]

Gregory S Weinstein worked with the *daVinci* robot. He performed *Transoral Robotic Surgery (TORS)* at university of Pennsylvania. Surgeries such as partial laryngectomies, submandibular gland ablations and selective neck dissections were performed. *TORS* proved to be beneficial and it provided better visualization. Moreover, it provided access to tumors via minimally invasive, less morbid approach which further resulted in overall functional results.[16]

Transoral nasopharyngectomy was performed in 2010 by *William I. Wei.* It was performed in a patient who was diagnosed with recurrent carcinoma of nasopharyngeal region. Split palatal approach was used to expose the entire nasopharynx and pathology was removed using two robotic arms along with camera. [17]

It was in the year 2010, that the 1st description of using surgical robots for removing the salivary stones was presented by *Rohan R Walvekar, et al.* The *daVinci Si* system was used to perform a *Transoral Sialolithiotomy* along with sialoendoscopy. The total duration for the surgery came out to be approximately 120 minutes. Further, they stated the advantages of the *daVinci* surgical system in terms of excellent visualization, improved magnification and dexterity for removal of stone trans-orally while preserving the lingual nerve and submandibular duct. [10]

In 2011, the limitations of using robotics in field of head and neck surgery were listed by *Dallan, et al.* According to them due to the narrowed area of work, the arms of the robotic system should work parallelly which will further prevent the chances of conflict. The advantages of robotic skull base surgeries were discussed which included frameless neuro-navigation, intra-operative imaging systems, modular approaches, etc. [10]

It was in the year 2011, that *Johan Martell et al* advocated the limitations of using the robotic systems such as the lack of the tactile sensation. A binocular with high resolution was incorporated. Sensory feedback was provided with the help of the visual clues. Deflection of membrane that was being manipulated was visualized to calculate the suture strain. This lacuna of sensory feedback in robot assisted surgeries was expected to be compensated by this real time feedback of suture tension. [10]

Another major obstacle was commented by *Prem N Kakar et al* in 2011. According to him, this obstacle was termed as the *'latent time'*, which meant the time that was required to send an electric signal from the hand while in motion to the actual visualization of the moving hand on a distant screen. There was another robot that was able to act like an anaesthesiologist and this was termed as *"Mc Sleepy".* It was able to perform functions like analyzing the biological information, adapting its own behavior and recognizing monitoring malfunction.[2]

Since, the chances of morbidity are high in conventional open surgical techniques, are technically sensitive and can prove to be uncomfortable to the patients, chemoradiation has become a common option for the primary management of the oropharyngeal cancers. However, this chemoradiation has adverse effects of its own which include xerostomia, dysphagia and can also result in late complications such as trismus and osteoradionecrosis. In order to overcome these adverse effects of the chemoradiation, *Transoral robotic surgery (TORS)* can be preferred. This is a minimally invasive technique that provides more precise results with less morbidity. This is possible because of the fact that this technique makes use of the oral cavity for the surgeries and no extraoral incisions are required.[18]

Robotic surgery is now beginning to see adoption in minds of many. With the phenomenon of no contact of surgeon with the patient during the surgeries, a new era of *'no infection, no antibiotic'* will emerge extensively.

The *daVinci* surgical system has been given approval by the FDA. These can be used for performing *TORS* procedures for the treatment of tumors of oropharyngeal region in adults. In future, surgeries on mobile structures, such as beating heart will be improved by creating an image in virtual stillness using the further advances in *'motion gating technology'.* [2]

SURGICAL ROBOTIC SYSTEMS FOR ORAL AND MAXILLOFACIAL SURGERY:

I. *RobaCKa system*
II. *daVinci System*

I. *RobaCKa System-* [6]

It was developed in by University of Karlsruhe (Institute for Process Control and Robotics) and the Ruprecht- Karls- University Heidelberg (Department of Oral- and Craniomaxillofacial Surgery). It was designed for performing craniotomies at the bony skull. It was the 1st ever system that was used to perform milling trajectories along with instruments which show permanent changes in their positions and orientations.

It was designed on the basis of *Caspar robot system*. This was further improved by improving safety using a redundant control system. This system was based on the robotic control, the infrared-navigation-system termed as *Polaris*, a sensor for force torque and an overload protection. Sensor-PC was used to control the supervision and sensor-fusion. The main role of this Sensor-PC was to run a real-time operating system. The infrared navigation system was used to monitor the position and the orientation of the instruments being used in order to ensure the safety. The robots were able to perform the functions using slow movements and that too only after conformation by the surgeons by pressing certain buttons.

These buttons were in direct connection with robot's emergency circuit. The power supply of the robot would completely cut within milliseconds if both the buttons are released simultaneously. Another button that was connected to the robot control, allowed the robot to move to a safer position before the surgeon stops intentionally. Graphical user interface (GUI) was used to support the control of the robotic system during the surgeries.

In the *RobaCKa-system*, this GUI was structured according the ''workflow concept''. This concept helped the surgeon by guiding the whole surgical procedure using a well-structured and clearly defined sequence and a clear graphical presentation. All this was done using only a few buttons. As described in Fig.4, diagnostic images and 3D models of the patient were generated for starting the complete surgical procedure. After that, *KasOp* software was used to simulate and plan the procedure. The last step of executing the trajectory accurately was performed by the robot intra-operatively.

This system was used for the first trial on a patient in the University Hospital Heidelberg. Another field of application of *''RobaCKa''* was its use in milling the beds for titanium implants. This was tested earlier on cadavers of sheep. It was necessary to build robots that are more dedicated in the field of craniofacial surgery.

II. <u>*daVinci System*</u>- [2]

It is a product of Intuitive Surgical System. It falls under the category of telesurgical devices. *daVinci Surgical System* was approved by FDA on July 11, 2000 for performing the laparoscopic procedures.

The 3 generations of *daVinci surgical systems* that have been developed so far are:

A. *daVinci surgical system* (1999)-

It consists of three components:

- The console for viewing and controlling
- Surgical arm unit
- Optical 3D vision tower

B. *daVinci S HD surgical system* (2006)-

This is the second generation of the *daVinci surgical robot.* It is equipped with the features such as wide range of motions of robotic arms and instruments with extended lengths, interactive video displays and touch screen monitor.

C. *daVinci Si HD surgical system* (2009)-

It has dual console capability. This helps in supporting the training and collaboration, advanced 3D HD visualization with up to 10× magnification. It also supports the 'EndoWrist'® instrumentation which has dexterity and range of motion which is more than the human hand. Further, it consists of the 'Intuitive® motion technology', which is responsible for replicating the experience of open surgery while preserving the alignment in a natural eye-hand position.

Innovations incorporated in the *daVinci* system-

These innovations were made to incorporate the substantial improvements which were lacking in the conventional endoscopic surgery. These were as follows:

a. It consisted of true three-dimensional imaging using the twin-mounted 5-ram endoscopes. These helped in projecting separately to the left and right eye.
b. Improvement in versatility and flexibility of operative instruments was seen in the distal articulation of EndoWrist instrumentation.

Operating with the help of a *daVinci* surgical system- [2]

Once the patient is positioned, 3 - 4 small incisions are made on the patient's body depending on the arms present on the model. There are 2 endoscopic cameras present on a single port that helps in providing the stereoscopic image. Rest of the ports are equipped with the arms that are dedicated to perform the surgical procedures of dissecting and suturing.

The surgeon sitting at the surgeon console, looks at 2 separate monitors. Independent camera channel produces the virtual 3D stereoscopic image that is visualized by the surgeon using both the eyes. There is a joystick-like instrument that is present below the screen which helps the surgeon to manipulate the surgical instruments. As soon as the surgeon makes any movement, an electrical signal is sent to one of the instruments. This is how the instrument moves in synchronization with the movement of the surgeon's hand. A 'frequency filter' device eliminates the hand tremors that are greater than 6 Hz allowing the surgeon to work on a miniature scale. Another device termed as the 'motion scaling device' scales the movement of the surgeon's hand up to a ratio of 5:1.

daVinci system is the only FDA-approved robotic surgical system that is being currently used in the field of head and neck surgeries**.** [19]

TRANSORAL ROBOTIC SURGERY (TORS) IN ORAL AND MAXILLOFACIAL SURGERY:

In the year 2005, McLeod and *Melder* reported the 1st use of the *daVinci* surgical robotic system for performing the laryngeal surgery. This system was used to excise a vallecular cyst. There were no complications reported in any of the patients an all were discharged on the same day of the surgery.

Later, in 2005, technical feasibility of using *daVinci* robotic system for performing airway surgery on a mannequin and cadavers were reported by *Hockstein* and colleagues. The success of the cadaveric surgeries further led to the use of robotic systems in performing procedures such as *Transoral Robotic (TORS)* supraglottic partial laryngectomy and resection of neoplasms present on the base of tongue. The studies on robotic systems in various head and neck regions along with their outcomes have been shown in table 1 [20] whereas table 2 [21] depicts the long term and short-term gastrostomy tube dependency rates following *TORS.*

Authors	Subjects (numbers)	Anatomic regions/sites approached/resected (numbers)	Airway	Swallowing/feeding	Average blood loss	Average hospital stay	Follow up	Remarks
Weinstein et al.	Patients (29)	Oral cavity, Oropharynx and Laryngopharynx	74% extubated successfully and rest did not require permanent tracheotomy	96% were without gastrotomy tube on last follow-up	189 ml	NR	6 months	One patient developed distant metastasis on the follow up, 50% resection of base of tongue associated with dysphagia.
Genden et al.	Patients (20) of these 18 patients only operated due to lack of exposure	Base of tongue (3) Tonsil (7) Posterior pharyngeal wall (3) Supraglottic Larynx (3) Parapharyngeal space (2)	None of patients required tracheotomy	Oral diet started between 1 and 3 days	80 ml	1.7 days	4 months	–
Moore et al.	Patients (45)	Base of tongue (26) Tonsillar fossa (19)	The mean duration of tracheotomy tube in situ was 7 days	Average duration of NG tube placement was 12.5 days, 8 PEG placed eventually removed, 88.9% swallowing orally at 4 weeks	12.6 ml	3.8 days	12.3 months	No major complication and no procedure aborted
Boudreau et al.	Patients (36) of these 29 patients had successful resection	Oral cavity (3) Oropharynx (22) Hypopharynx (1) Larynx (10)	72% were extubated post-op. Rest of the patients were extubated safely in one week.	89% started oral intake by 2 weeks	51 ml	2.9 days	NR	Guidelines proposed: (1) lower T classification, edentulous patients with successful resection, (2) gastrotomy tube dependence predicted by advanced age, tumour location in larynx, higher T classification, lower MDADI score
Iseli et al.	Patients (62) of these, 54 patients had successful resection	Oral cavity (6) Oropharynx (33) Larynx (12) Hypopharynx (3)	Tracheotomy done in 9%, all were decannulated by 14 days	Within 2 weeks 83% were on oral intake	NR	63% were discharged in 1–2 days; few 6% stayed back longer than one week	13 months	Retained postoperative feeding tube was associated with preoperative tube requirement, higher T stage, oropharyngeal/laryngeal tumour site), and the tumour being recurrent or a second primary tumour
O'Malley et al.	Patient (1)	Parapharyngeal space and Infratemporal fossa	No tracheostomy required	Clear fluids in the immediate postoperative period	50 ml	2 days (average duration of surgery: 2 h 32 min)	NR	Suitable for well circumscribed benign lesions
O'Malley et al.	Cadaver (1) and live mongrel dog (1)	Anterior and middle cranial fossa, Midline skull base, Sella, parasellar, and suprasellar regions	NA	NA	NA	NA	NA	Still in experimental stage
Hanna et al.	Cadavers (4)	Anterior and middle cranial fossa Cribriform plate, Fovea ethmoidalis, Medial orbits, Planum sphenoidale, Sella turcica, Suprasellar and parasellar regions, Nasopharynx, Pterygopalatine fossa and clivus	NA	NA	NA	NA	NA	Still in experimental stage. Advantages offered: 3 D visualization, four arms of the robot which permit tremor free closure of dural defects
Rahbar et al.	Patients (5) Paediatric airway Successful closure of type I and type II laryngeal cleft in two	Paediatric airway	NR	NR	NR	NR	NR	Obtaining proper exposure and smaller instruments is required

	patients, procedure abandoned in three patients because of lack of exposure							
Lewis et al.	Cadavers (5) Patient (1)	Thyroid Transaxillary hermithyroidectomy was performed without gas	NR	NR	NR	NR	NR	Used for follicular neoplasm
Miyano et al.	Patients (2)	Thyroid Bilateral transaxillary total thyroidectomy performed using gas insufflation	NR	NR	NR	NR	NR	Used for benign thyroid disease
Haus et al.	Procine model	Thymectomy Submandibular gland excision Parotidectomy and Neck dissection	NA	NA	NA	NA	NA	In experimental stage

Table 1: Outcomes of studies on robotics in various head and neck surgeries

Table Courtesy: 27. Garg A, Dwivedi R C, Sayed S, Katna R, Komorowski A, Pathak K A. Robotic surgery in head and neck cancer: a review. Oral Oncology 2010;46:571-76.

S.No.	Study	Short Term	1 year	2 years
1.	Weinstein et al. (2010)	18%	2.40%	0%
2.	Moore et al. (2009)		0%	0%
3.	Iseli et al. (2009)		9.50%	
4.	Genden et al. (2011)		0%	0%

Table 2: Long term and short-term gastrostomy tube dependency rates following TORS

Table Courtesy: Dowthwaite S A, Franklin J A, Palma D A, Fung D, Yoo J, Nichola A C. The role of transoral robotic surgery in the management of oropharyngeal cancer: a review of the literature. Int J Cancer 2011:1-2.

Conclusion:

Robotic systems for performing surgeries have proved to be a new and exciting tool that is seeking adoption in the minds. Recently, the *daVinci Surgical System* has been approved by the FDA. This system is being used for *TORS* procedures such as oropharyngeal tumors in adults. Surgeries on mobile structures such as the beating heart can be improved with the advances in 'motion gating technology'. [2]

In India, only few centres have the availability of the surgical robots. The main lacunae of these systems are the high costs of the systems and the increased operative charges. The 1st Centre in India to acquire a surgical robot (*daVinci surgical system*) was the Escorts Heart Institute and Research Centre.

The first robotic urology surgery in India was performed in April, 2005. Further, in India, in 2008, the 1st robotic thoracic surgery (thoracoscopic thymectomy) was performed. Indigenous robotic surgical systems are now being worked upon by the collaboration between the CARE foundation and the Indian Institute of Information Technology (IIT) Hyderabad. [2]

These systems have the features that allow the robot controller to directly access the planning data. The robotic arms provide the high accuracy and precision independent of the progress of the operative time. This in turn provides the benefit of achieving high quality in the operation theater. The use of surgical robots in performing the procedures in craniofacial surgery is considered to be reasonable because of the presence of vital structures in the vicinity and great impact of bone repositioning at human skull. [22]

Despite of the advantages, these systems have to be more mature in order to be incorporated in the daily routine. This leads to the requirement of smaller systems which are more suitable for the operating room. Former industrial robots are not required to be used in routine procedures because of their clumsiness. Moreover, there is requirement of high efforts in order to make them safe, sterile and clinically practicable. The intra-operative planning lays the basis of the new concepts of the computer assisted surgeries. This will lead to the incorporation of the features of intra-operative CT or MR compatible systems. Some research programmers have also devised robots for such environments; however, these are still far from their use in the clinical applications. [6]

TORS for treating the lesions present on the base of the tongue has shown significant advantages over both conventional open tongue base surgeries and laser microsurgeries. Both the functional as well as cosmetic outcomes have negative effects after the conventional open surgeries. Procedures such as mandibulotomy with a lip split or visor flap or transpharyngeal approaches have shown adverse effects on mastication, swallowing, speech and cosmesis. These adverse effects can be eliminated using the *TORS*. The open surgical procedures have an added risk of infection because of the formation of a communication between the oral cavity and the neck. Moreover, open surgeries may require tracheostomy which is not the case with the *TORS* tongue resection. All these advantages of *TORS* has proved it to have a promising application in human trials and this might further prove to be a valuable minimally invasive and low morbidity therapy for the management of the tongue neoplasms. [23]

The use of *daVinci® Surgical Systems* in the field of OMFS has been found to be promising on the basis of the results reported in the literature. In management of oropharyngeal tumors, *TORS* may provide an organ preserving approach. This also leads to no requirement of conventional lip-split mandibulotomy. It can be used in managing the benign and malignant lesions and also for the surgical management of sleep hypopnea syndrome which might be caused due to the hypertrophy of the base of tongue. It also leads to improved precision of vascular anastomoses in the field of oromaxillofacial reconstructive surgery. Further prospective clinical studies are required to prove the feasibility of its use in *OMFS*. [3]

Given below is the list of *Transoral Robotic Surgery (TORS)* procedures: [12]

- Radical tonsillectomy
- Tongue base resection
- Supraglottic laryngectomy
- Partial laryngectomy
- Hypopharyngectomy
- Total laryngectomy
- Robot assisted transoral laser excision within the oropharynx, larynx, and hypopharynx
- Robot assisted surgeries in setting of flaps
- Microvascular anastomosis for free flaps

- Robot assisted lingual tonsillectomy for sleep apnea
- Robot assisted resection of tumors of parapharyngeal region
- Nasopharyngectomy

The major limitation of robotic surgery that is being worked on now is the lack of tactile feedback. While performing the conventional surgeries, the surgeons are well versed with the hepatic feedback, and the sense of temperature, pressure, tension and vibrations, which is lacking in the surgeries performed by the robotic systems. The new transformations are being tried in order to address these limitations of the robotic surgeries by providing the surgeons with the real time sensory feedback.[5]

Patients who undergo conventional open surgical procedures such as mandibulotomy or pharyngotomy have to encounter severe cosmetic deformity, occlusal disharmony and dysphagia. These approaches further lead to negative impact on quality of life of the patients and may give rise to a condition where there is a requirement of gastrostomy tube or tracheotomy for long term. These results in speech and swallowing dysfunctions. All these shortcomings of the conventional open surgeries can be overcome by using the robot assisted surgeries. These robotic surgeries have many advantages over the conventional one which includes better visualization, minimal invasive nature, improved hemostasis, improved instrument movement.

These advantages are responsible for a clear visualization of the lesion, reduces the duration of the hospital stay, improved function, freedom of movement, preservation and maintenance of the post-operative quality of life of the patient. Several reports have demonstrated that *TORS* may have great potential in order to access the oropharynx and the supraglottic larynx with less morbidity. [24]

The introduction of robotic surgery, will lead to separation of patient from human contact during surgery, which may bring the era of *'no infection, no antibiotic'.*

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How to cite this article: Johari S, Gupta D.S, ArunKumar K.V. Application of Robotics in Oral & Maxillofacial Surgery: Literature Review. TMU J Dent. *2020; 7(4):12-21.*