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ORIGINAL ARTICLE

Transoral robotic surgery using the Medrobotic Flex® system: the Adelaide experience

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Abstract

Transoral robotic surgery (TORS) has become an accepted treatment option for a variety of benign and malignant pathologies of the head and neck. The Medrobotics Flex® system is a novel single port platform available as an alternative tool to current multiport robotic technology. We present the Adelaide experience with this system thus far. The Medrobotics Flex® system was introduced in Adelaide in January 2017. Patient demographics, pathology, indication for surgery and complications are prospectively recorded for all cases. The first 20 patients are presented in this case series. 11/20 underwent surgery for malignant disease. Of these nine were diagnosed with oropharyngeal squamous cell carcinoma (OPSCC). Histopathology revealed clear margins of primary tumour excision in 8/9 patients. There were no intraoperative complications. In terms of secondary complications, one patient undergoing tonsillectomy for recurrent tonsillitis experienced a secondary haemorrhage at day 13 following operation and one patient undergoing lateral oropharyngectomy for pT3N2b tonsillar SCC sustained an oro-cervical fistula, which settled with conservative management. We have found the Medrobotic Flex® system to be a safe, reliable tool for managing transoral surgery. The range of pathology managed with this platform, as well as the histologic outcomes presented, demonstrates efficacy in the oropharynx and posterior oral cavity for both benign and malignant disease.

Keywords Trans-oral surgery · Robotic surgery · Oropharyngeal squamous cell carcinoma · Head and neck surgery

Introduction

Despite reductions in smoking in developed countries, the incidence of oropharyngeal squamous cell carcinoma (OPSCC) is rising across the world [1]. Though primarily thought to be related to human papilloma virus (HPV) there is evidence that this rise in incidence is not solely attributable to HPV and that the rates of non-HPV associated OPSCC is also rising [2]. Regardless, the majority of patients with OPSCC today have a virally driven disease and are younger than the traditional head and neck cancer patient [3]. They also tend to lack tobacco and alcohol as risk factors. The younger age of these patients means the life-long and progressive late-effects of radical chemoradiotherapy (such as dysphagia, osteoradionecrosis, xerostomia, skin changes and muscle fibrosis) may present an even greater burden and detriment to quality of life [4]. Transoral surgery has become an essential component of the multidisciplinary treatment options available to the patient, as tumours excised with clear surgical margins with pathologically favourable neck disease may lead to de-intensification of adjuvant therapies that carry a significant risk of toxicity.

Huet first reported transoral surgery for an oropharyngeal tumour in 1951 using electrocautery [5]. Steiner and Ambrosch described transoral laser microsurgery for laryngeal and oropharyngeal carcinomas [6]. Weinstein et al. demonstrated the transoral use of the first commercially available surgical robot (Da Vinci, Intuitive Surgical, Inc., Sunnyvale, CA) and underpinned the FDA approval of this in T1–T2 oropharyngeal tumours [7, 8].

Transoral robotic surgery (TORS) improves visualisation and access to the oropharynx increasing the spectrum of disease able to be managed without more radical,

This paper is not based on previous communications to a society or a meeting.

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open-approach surgery. The Da Vinci system uses rigid three-dimensional (3D) endoscopes and robotic arms. Some have raised concerns over the relatively high running costs and lack of haptic feedback. The camera and arms are rigid and relatively bulky, which can present difficulties in the upper aerodigestive tract [9–11].

The Flex® robotic system (Medrobotics Corp., Raynham, MA) was designed specifically for head and neck surgery and provides a flexible endoscope with flexible instruments which conform to the upper aerodigestive tract as well as providing tactile feedback to the surgeon [12, 13].

The Medrobotics Flex® system consists of a highly articulated robotically driven endoscope cart a High Definition (HD) screen and a robotic camera control console (see Fig. 1). On either side of the endoscope are apertures, which allow the flexible instruments to be introduced through the same single port (see Fig. 2). The control console is easily placed within reach of the operating surgeon without blocking the assisting nurse or interfering with the operative instrument control.

Our department has had extensive experience with the Da Vinci system over the last decade, being one of the earliest adopters of this technology. We now report our first 20 transoral cases with the Flex® robotic platform. To our knowledge, it is the first preliminary case series published outside the United States and Europe [13], providing valuable insight from an Australasian perspective as the platform gains more interest amongst local head and neck surgeons.

Fig. 1 Photo of components of Medrobotics Flex system. From left to right these comprise the robotic endoscope cart, the HD screen and the robotic control console

Fig. 2 Photo of flexible instruments passed through the single port system

Methods

The Medrobotic Flex® system was introduced in Adelaide in January 2017. All cases performed were prospectively logged and monitored to provide quality assurance for safety and efficacy. All patients gave informed consent for this technology to be used for their surgery. Patients underwent transnasal intubation to maximise transoral access. Each patient was positioned supine with a shoulder roll and head ring used to maximise neck extension and stabilise the head. The surgical assistant provided retraction and smoke evacuation as well as the application of vessel ligation clips as needed. For robotic tissue handling a Maryland dissector was used as well as a fenestrated forceps and a monopolar spatula or needle knife was used.

Details of each patient including pathology, diagnosis, procedure and successful completion of procedure were recorded. Both intraoperative and postoperative complications were recorded as well as resection margins and the impact of these on the requirement for any adjuvant therapy.

Haemostasis was obtained using diathermy and titanium vessel clips. At the end of surgery an anaesthetic Valsalva manoeuvre was performed on all patients to ensure adequate haemostasis and a haemostatic gel applied topically to the surgical bed.

Results

Twenty-one patients in total were offered TORS using the Medrobotic Flex® system (see Table 1). One patient was excluded from further analysis as the operation was for

Table 1 Details of patient age, pathology, operation performed and length of stay

Patient number	Patient age (years)	Pathology	Operation	Length of stay (nights)
1	65	SRBD	Lingual tonsillectomy	2
2	19	Tonsilliths	Tonsillectomy	1
3	38	OPSCC	Lateral oropharyngectomy	6
4	33	Tonsillitis	Tonsillectomy	1
5	67	OPSCC	Lateral oropharyngectomy	14
6	79	Valleculla cyst	Excision of valleculla cyst	1
7	59	OPSCC	Lateral oropharyngectomy	7
8	71	OSCC	Wide local excision retromolar trigone	0
9	43	OPSCC	Lateral oropharyngectomy	7
10	63	OPSCC	BOT mucosectomy	6
11	65	OPSCC	BOT resection	10
12	69	CUP	Tonsillectomy, BOT mucosectomy	7
13	60	BOT lesion	Partial glossectomy	2
14	78	OPSCC	Lateral oropharyngectomy	5
15	63	Lingual tonsillitis	Lingual tonsillectomy	1
16	33	Tonsillitis	Tonsillectomy	1
17	60	OSCC	Partial glossectomy	5
18	66	CUP	BOT mucosectomy	4
19	57	OPSCC	Right partial glossectomy	9
20	43	SRBD	Lingual tonsillectomy	1

laryngeal pathology and was abandoned early in the procedure due to lack of accessibility being identified quickly. The remaining 20 patients comprised 14 men and 6 women with a mean age of 57 years (range 19–79 years). A range of pathology was addressed (see Table 2). 11/20 patients underwent transoral robotic surgery (TORS) for malignant disease. In three of these a base of tongue mucosectomy was performed to potentially identify an unknown primary tumour site. The primary tumour was identified in one mucosectomy and completely excised at the same time. In the other two cases no UADT primary tumour was identified following surgery. The final immunohistochemistry from simultaneous neck dissection revealed the underlying pathology to be sarcoma and a likely cutaneous primary tumour rather than UADT SCC in these cases.

The mean length of stay was 4.5 nights (range 0–14), all patients operated on due to benign pathology were discharged within 48 h once analgesic requirements could be met orally.

In all patients, the procedure was deemed successfully completed at the end of surgery. There were no intraoperative complications during any of the procedures showing the excellent safety profile of this technology.

Table 2 Details of patients undergoing TORS with the Flex system for HNSCC

Subsite	Stage (TNM 7)	Stage (TNM 8)	Margins of primary tumour
Tonsil	T2N3	T2N1	Clear
Tonsil	T3N2b	T3N2	Involved BOT, deep and lateral
Tonsil	T2N2b	T2N2	Clear
Tonsil	T2N2a	T2N1	Clear
BOT	T1N2b	T1N2	Clear
BOT	T1N0	T1N0	Clear
Tonsil	T1N3	T1N1	Clear
BOT	T2N2b	T2N2	Clear
BOT	T2N1	T2N1	Clear
BOT	T0N2b	N/A	N/A—no primary identified (likely cutaneous primary)
BOT	N/A	N/A	N/A—no primary identified (sarcoma)

There were two post-operative complications; one patient undergoing tonsillectomy for recurrent tonsillitis experienced a secondary haemorrhage at day 13 post-operatively. One patient undergoing lateral oropharyngectomy for pT3N2b tonsillar SCC suffered an oro-cervical fistula, which settled with conservative management and was discharged home at 7 days following surgery. There were no primary haemorrhages experienced in any patient.

Discussion

Adelaide was the first head and neck unit in Australia to undertake robotic transoral surgery in August 2008. Since then it has become an accepted treatment option for OPSCC throughout Australia and New Zealand. Our robotic practice has expanded to include a range of benign and malignant pathologies in the upper aerodigestive tract.

Single port vs multiport robotic approach

The senior authors all have comprehensive training and extensive experience in robotic surgery using the Da Vinci system. This is a multiport system designed with rigid instruments that fulcrum at the level of the mouth and use angled cameras to provide visual access to more distal anatomy. The Medrobotic Flex® system is the first commercially available single port robotic system designed for natural orifice surgery. The ability to conform to the shape of the upper aerodigestive tract means patients with potentially difficult access due to reduced mouth opening or neck extension may be operable with the Flex® system [14].

The Flex® has a robotically driven flexible 28 mm endoscope with two instruments which pass through sheaths positioned on either side of the same single port and are operated by the surgeon at the patient bedside, akin to laparoscopic surgery. Setup time currently sits at about 10 min with further reductions expected as expertise increases. Movement of the instruments, similar to laparoscopic procedures is non-intuitive (moving the surgeon's hand right moves the instrument left; moving the surgeon's hand up moves the instrument down). A number of instruments are available, including needle and spatula monopolar cautery, and fine and fenestrated grasping forceps. The single port system means there is no potential for clashing of ports intraoperatively. However, it does reduce the angle of approach and retraction of tissues possible due to the proximity and parallel positioning of the instruments.

The Flex® system provides the operating surgeon with both gross and minute tactile feedback. Optics in this study were 2D and high definition. A 3D camera is now available for the Flex® system. The flexible nature of the Flex® endoscopic camera means superior positioning allows the use of a 0° camera, obviating the need for angled lenses. Operating from a 0° camera provides the surgeon with an exact optical representation of the visualised anatomy, removing any errors of parallax. Currently the system provides magnification to 160%, however, pixilation and image degradation occurs at 115%.

Although a surgical assistant is not mandated it is useful to have one available to maximise retraction and tension on tissues and provide improved cautery plume evacuation. An assistant can also help in the application of ligaclips for haemostasis. Due to the support provided by the instrument sheaths the Flex® system instruments are essentially tremor filtrated which minimises the natural micro-movements that can distract when operating under magnification with long instruments. Instruments have been designed with laryngeal manipulation in mind, however, currently the size of the camera (28 mm) is still too large for consistent access to the larynx.

Training is an important issue for the introduction of any new surgical technology. Adelaide is currently the Australian centre for training in the Medrobotics Flex® system. The senior author feels a formal training system is necessary for using the Flex® system regardless of previous Da Vinci robotic experience. The different principles and control mechanisms of each robotic system mean there are few transferable elements in terms of robotic control between systems.

The Flex® monopolar needle diathermy instrument allows for precision dissection and also reduces artefact providing both an excellent operative field and clear histological specimens essential for TORS in malignant disease. This is supported by the histopathological margin results in this series. Of the nine patients who had tumours resected trans-orally in this group (see Table 2), histological margins were deemed to be clear in 8/9 patients (88%). These patients were diagnosed with oropharyngeal squamous cell carcinoma (OPSCC). Interestingly, 4/9 did not require any adjuvant therapy, following final histopathology, and only 1/9 required adjuvant therapy on the basis of positive surgical margins. Four patients received adjuvant therapy with 2/4 receiving adjuvant radiotherapy alone and 2/9 receiving adjuvant chemoradiotherapy (due to the presence of extracapsular spread in cervical lymph nodes).

The histopathology results of primary tumour resection in these patients demonstrate safe, precise tissue handling intraoperatively with the Flex® system. This is continuously audited by our network's multi-disciplinary team.

When assessing patient suitability for TORS using the Flex® system, the principles of assessing adequate mouth opening, Mallampati classification, retrognathia (hyoid-mental length) and neck extension is essential [15]. The authors also assess trans-oral access during preceding diagnostic panendoscopy and biopsy procedures.

In conclusion. we have found the Medrobotic Flex® system to be a safe, reliable tool for managing transoral surgery. The range of pathology and histologic outcomes we present demonstrate its efficacy in the oropharynx and posterior oral cavity for both benign and malignant disease. A carefully supervised, audited, individual training scheme is required to undertake surgery with this system and ensure adequate outcomes in terms of complications and successful resection.

Compliance with ethical standards

Conflict of interest Author Neeraj Sethi declares that they have no conflict of interest. Author Michael Gouzos declares that they have no conflict of interest. Author Vikram Padhye declares that they have no conflict of interest. Author Andrew Foreman declares that they have no conflict of interest. Author E. H. Ooi declares that they have no conflicts of interest. Author Suren Krishnan has received educational grants from Medrobotic. Author J.C. Hodge has received educational grants from Medrobotic.

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