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HEAD AND NECK CANCERS (EY HANNA, SECTION EDITOR)

Robotic Head and Neck Surgery: Beyond TORS

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Abstract

Purpose of Review To explore the advances in robotic head and neck surgery (HNS) beyond TORS.

Recent Findings Although limited, the current literature corroborates the safety of robotic neck surgery, revealing similar surgical/oncologic outcomes, except longer operative time and superior cosmesis. In most of the remote thyroid approaches, use of robotic-assisted surgery is essential. However, for the recently popularized transoral approach, endoscopic technique has been preferred by most surgeons, due to longer operative time in robotic-assisted technique. On the other hand, retroauricular approach has been considered the standard for comprehensive/selective robotic neck dissections.

Summary Robotic technology has an increasing role in HNS. Robotic neck dissection has shown encouraging results, being routinely used in some centers around the globe. Robotic thyroid surgery, although safe when well applied, has lost ground to endoscopic transoral thyroidectomy. In the future, more evolved robotic systems could improve multiple areas of HNS.

Keywords Robotic surgery · Robotic neck dissection · Robotic thyroidectomy · Robotic thyroid surgery · Robotic neck surgery · TORS · Transoral robotic surgery · Retroauricular neck dissection · Retroauricular thyroidectomy · Transoral thyroidectomy · Transoral thyroid surgery

Introduction

Robotic surgery is one of the most recent advances in head and neck surgical oncology. The use of the da Vinci Robotic Surgical System (Intuitive Surgical, Inc., Sunnyvale, CA) in head and neck surgery (HNS) was first described in 2005 by McLeod and Melder, performing a vallecula cyst resection [1]. In the following years, numerous studies showed that minimally invasive transoral robotic surgery (TORS) could be an option for the treatment of selected patients with early stage oropharyngeal carcinomas because of the better functional results and favorable oncologic outcomes when compared with standard surgical techniques or chemoradiation [2–9]. In 2009, the US Food and Drug Administration (FDA) approved the use of the da Vinci Robotic System for transoral procedures, promoting resurgence in the enthusiasm for primary surgical treatment of OPSCC. Nowadays, TORS is an increasingly established standard treatment in initial oropharyngeal and supraglottic carcinomas, being routinely used in most of the reference oncologic centers around the globe [5].

In parallel to the development and establishment of transoral robotic surgery among head and neck surgeons, the combination of this highly technological new surgical tool with the determination to limit esthetic and psychosocial consequences of some procedures as neck dissections and thyroid surgery has driven the development of different remote access approaches to the neck [10–18]. These new approaches gained enthusiasm especially in Asia, where cultural aspects motivate patients to avoid a visible neck scar [19], and expanded the potential roles of robotically assisted surgery in head and neck. However, due to various concerns of exposure and visualization, many head and neck surgeons remain hesitant to use these modalities of minimal invasive techniques, despite encouraging initial safety and oncological outcomes demonstrated by the early adopters' groups [14, 20–22, 23•, 24, 25, 26•], sustaining significant controversy around the effectiveness of such procedures when compared with conventional well-stablished techniques [27, 28].

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In this review, we will explore the use of robotic surgery in head and neck field beyond TORS, focusing essentially in robotically assisted techniques using remote approaches to the neck.

Robotic Thyroid Surgery

Thyroidectomy is the most frequently performed procedure by the majority of head and neck surgeons around the world. The increasing incidence of thyroid cancer is making it even more common. Although conventionally performed through a 4-5 cm horizontal incision in the lower neck, within the last years, there has been a great debate on the impact of such scar [27, 29–32]. Besides cosmesis and esthetic concerns, the need for post-operative scar care and the impact of a visible neck scar on social interactions could also be a part of the patient's decision about thyroid surgical approach [33•].

In this scenario, multiple alternative approaches to the thyroid gland were described and successfully performed in the last 10 years, using both endoscopic- and robotic-assisted techniques [19]. Of these, robotic thyroidectomy via transaxillary and retroauricular (or modified facelift) approaches, respectively described by Chung in 2009 [22] and Terris in 2011 [12], were the ones that first gained some popularity outside Asia [24, 25, 27, 28, 34–38].

Robotic thyroid surgery have shown good results regarding safety and oncologic outcomes in several publications [12, 14, 22, 24, 25, 34, 36–46], including five systematic reviews [40, 43, 47–49]. In these reviews, the common conclusions are that robotic thyroidectomy, when compared with conventional technique, has longer operative time and higher cosmetic satisfaction, with similar surgical and oncological safety. Although these findings suggest that would be easy to trade longer operative time in exchange for higher cosmetic satisfaction in selected patients that are motivated to avoid a visible neck scar, several obstacles emerged interfering in the popularization of robotic thyroid surgery in western world. Among these obstacles, stand out the steep learning curve and the naturally difficult access to the contralateral thyroid lobe while using unilateral transaxillary or retroauricular approach. Even if growing experience mitigate these difficulties as shown by some Korean groups [14, 22], they certainly limited the routine use of these robotic approaches to Asia and some high-volume thyroid centers in Europe and America. In the USA, interestingly, was observed another important obstacle: in the first years following transaxillary technique description by Chung [11], most of the US robotic thyroidectomies were performed at low-volume centers, which resulted in higher complication rates and led the surgical robotic manufacturer to stop promoting their device for thyroid surgery [28].

In 2014, Wang et al. published the first series of 12 living patients that were successfully treated with endoscopic-assisted transoral thyroidectomy [50]. Shortly after, Hoon Yub Kim published 4 cases of robotic transoral thyroidectomies [51] and Angkoon Anuwong published 60 cases of transoral endoscopic thyroidectomy through a vestibular approach (TOETVA) [15], without any major complications and any case of mental nerve injury. Following Anuwong's publication, TOETVA gained progressively more supporters around the World, including in the USA, where several groups adopted TOETVA as a safe option for "scarless" thyroid surgery in very well selected patients [52–54]. There are some significant advantages of using TOETVA that helped its fast initial propagation: bilateral full access to the thyroid gland and central neck compartment; true NOTES and scarless procedure; no mandatory use of any robotic system (the great majority of published series were performed with laparoscopic instrumentation) probably resulting in lower costs and wider accessibility; and safety on initial oncologic outcomes evaluation [52, 53, 55, 56•, 57–61]. Anuwong has done more than a thousand TOETVAs so far, and some other groups are in the hundreds. This growing experience certainly will clarify the real benefits and define the proper indications and contraindications of TOETVA, establishing its role as a safe scarless option for thyroidectomy in selected cases. Although most authors do not advocate the use of robotic system in transoral thyroidectomy, some groups gained experience in transoral robotic thyroidectomy (TORT). Hoon Yub Kim's group have been the most prolific one exploring this robotic approach using 4 portals (3 in the inferior vestibule—similar to TOETVA—and a fourth in the axilla) [26, 62–66]. This group has demonstrated similar surgical outcomes comparing TORT and conventional thyroid surgery, besides longer operative time [66]. Other Korean group with experience in both endoscopic and robotic transoral thyroidectomy also showed similar surgical and oncological outcome between transoral and conventional approaches, with longer operative time in the transoral group. In the same article, they also found that robotic had a significantly longer operative time than endoscopic technique [67]. The new single port robotic system is already been used for transoral robotic thyroid surgery; however, very preliminary, the results seem comparable with the other transoral techniques [68].

Since 2014, our group has performed 200 thyroidectomies using remote approaches combined with endoscopic- or robotic-assisted techniques. Retroauricular approach was applied in 88 cases, with 76 robotic thyroidectomies, of which 28 combined with robotic neck dissection. We also had 112 transoral thyroid surgeries, and in only 3 of them robotic surgical systems were used. In the other 109, we performed TOETVA as described by Anuwong [15], using laparoscopic instrumentation. In our experience, these two remote approaches are safe and oncologically sound, presenting outcomes comparable with conventional surgery, except for the longer operative time and higher esthetic satisfaction [25]. In the same period, we had more than 4000 conventional thyroidectomies. Currently, we offer TOETVA to patients with < 2 cm papillary thyroid carcinoma (PTC) and < 4 cm benign nodules, and retroauricular robotic surgery for large benign unilateral goiters (4–8 cm) and patients with PTC with lateral neck lymph node metastasis, in which we perform thyroidectomy combined with neck dissection including levels II-VI [25].

Robotic Neck Dissection

Neck dissection is one of the pillars in treatment of mucosal head and neck carcinomas, as well as salivary gland and thyroid cancer. Nevertheless, even selective neck dissections are still associated with large visible scars, lymphatic drainage impairment, and fibrosis [69–71].

The evolution of endoscopic- and robotic-assisted surgery provided the tools for development of remote approaches to the neck. Subsequently, some of these approaches began to be used for neck dissections, with the rationale of avoid a visible large neck scar usually necessary for such procedures that can be strongly unwelcome in most of the patients [13, 14, 72–75]. The first series of robotic neck dissection using retroauricular or transaxillary approaches came from Korea, demonstrating its feasibility for thyroid carcinoma with lateral neck metastasis [16, 74, 76]. Following, Koh and Choi were responsible for initial propagation and establishment of retroauricular robotic approach as a safe way to perform comprehensive and selective neck dissections, through several publications and dissection courses attended by surgeons from multiple countries [14, 17, 20, 24, 72, 77–79]. Nowadays, it is the most commonly used approach for robotic neck dissection for mucosal head and neck, salivary gland, and thyroid cancer. It is performed in an anatomical area that is well-known for the head and neck surgeon, closer to the critical neck vessels and nerves, allowing even direct view and palpation during neck dissection together with excellent robotic visualization and proper dissection of ipsilateral neck from levels I to VII. Avoiding a large transverse neck incision and scar can potentially reduce the risk of great vessel exposure in case of skin dehiscence and the facial/submandibular lymphedema, besides the cosmetic benefit. Another important advantage of the retroauricular robotic approach is its versatility, allowing also thyroidectomies, free flap anastomosis, and salivary gland resection [77, 80–83].

Surgical and oncological outcome analysis in neck dissection technical evolution a difficult task, mainly because, although it is a highly standardized procedure, the primary tumor and its resection have a great impact in both. Besides that, other limitations as heterogeneity of methodology and inherent selection bias can be pointed out in most of the evaluable data. So far, all published series have shown satisfactory safety and early oncologic outcomes, without any reported major complication or surgery related death [14, 17, 23•, 25, 77–79, 84–88]. A recently published systematic review and meta-analysis including 11 studies and more than 200 robotic neck procedures found similar results regarding hospital stay, lymph node yield, and recurrence when comparing robotic with conventional neck dissection. Not surprisingly, the operative time was significantly longer in the robotic group [89••].

Esthetic and cosmesis objective analysis are also very difficult in this scenario due to the lack of specific metrics and heterogeneity of patients' individual cosmetic values. Subjectively, avoiding a visible anterior neck scar of 10-15 cm appears to have a clear esthetic advantage; however, it is important to seek objective data that could prove it, justifying the higher cost and longer operative time of robotic neck dissection. In the previously mentioned systematic review and meta-analysis, all five included studies that assessed cosmesis showed a significantly higher satisfaction in patients submitted to robotic neck dissection when compared with conventional approach [89••]. In a prospective study by Ji et al. [90], robotic neck dissection clearly showed significant advantage on cosmetic satisfaction when compared with conventional surgery. The only study that analyzed functional outcomes such as edema, fibrosis, movement, and sensory loss following neck dissection found lesser postoperative neck edema and sensory loss in the robotic group in the early postoperative period [90].

We have a growing experience, with more than 150 retroauricular robotic and endoscopic neck dissections, especially in oral, oropharyngeal, and thyroid carcinomas. Our outcomes have been explored in different publications, looking in particular for safety and oncologic effectiveness [23•, 24, 25, 80, 91, 92]. We found that robotic and endoscopic neck dissection for oral cancer had similar lymph node yield and recurrence free survival when compared with conventional neck dissection in our patients. Besides that, surgical quality assessment revealed satisfactory surgical outcomes. The only disadvantage to conventional neck dissection was longer operative time [23•]. In thyroid cancer, we are using retroauricular approach for lateral neck dissection (levels IIa–Vb) combined or not with central compartment dissection and thyroidectomy. Our published results analyzing variations of thyroid surgery and neck dissection for papillary thyroid carcinoma show a low complication rate, good surgical outcomes, and a mean lymph node yield above 25 [25]. So far, with 42 dissections performed for well-differentiated thyroid carcinoma, we had only one (2.4%) recurrence in a dissected neck side in a mean follow-up of 27 months, without any persistent hypocalcemia or persistent vocal cord palsy. For oropharyngeal carcinoma, we are combining TORS with retroauricular robotic neck dissection in most cases selected to upfront surgical treatment, believing that it is the best way to reduce scars and achieve the lowest surgical morbidity possible, resulting in patients with no visible scars. In our 24 cases experience using this combination for oropharynx cancer treatment, we had no recurrences in a mean follow-up time of 29 months. The Yonsei University head and neck group reached similar outcomes using this combination for oropharyngeal carcinomas in 37 patients, ratifying its feasibility and oncologic effectiveness [20] In our experience, based on subjective analysis, we encountered better esthetic outcomes in retroauricular robotic neck dissection than in conventional neck dissection. (Fig. 1).

Other Robotic Procedures in Neck Surgery

Submandibular gland excision and neck benign tumors resection are examples of other robotic-assisted procedures that can be performed using retroauricular or facelift approaches, with encouraging results [92–94]. As well as in robotic neck dissection and robotic thyroid surgery, the main appeal is to avoid a visible neck. However, magnified view and precise dissection could be considered significant advantages.

Future Directions

The DaVinci Robotic System®, the most commonly used robotic system nowadays, brought many technical enhancements when compared with conventional or endoscopic-assisted surgery, such as wide range wrist motion, tremor filter, precise de-escalated movements, and magnified 3D visualization. The increasingly dynamic technological innovation and the several new robotic surgery platforms being developed currently will change the scenario shortly, and in a few years, we will have more suited robots equipped with cutting edge technology such as augmented reality, surgical navigation, and advanced optics that could improve several aspects of HNS as we know today.

Conclusions

Robotic surgical technology has an increasing role in HNS. Beyond TORS, a well-stablished standard procedure in oropharynx tumors, robotic surgery can be applied for neck dissections, thyroid surgery, and salivary gland resections using remote approaches, avoiding visible neck scars. Although still limited, all the current evidence corroborates its safety and oncological soundness, associated with higher patient cosmetic satisfaction but longer operative time. Quality of life and functional outcomes beyond cosmetic satisfaction have been poorly explored so far. The impact of a large visible neck scar and its impacts on social interactions could be underestimated as well as post-operative edema and fibrosis that also could be improved. The higher cost represents another obstacle for robotic surgery routine application, but it can be highly variable according to the country and health care system. Future of

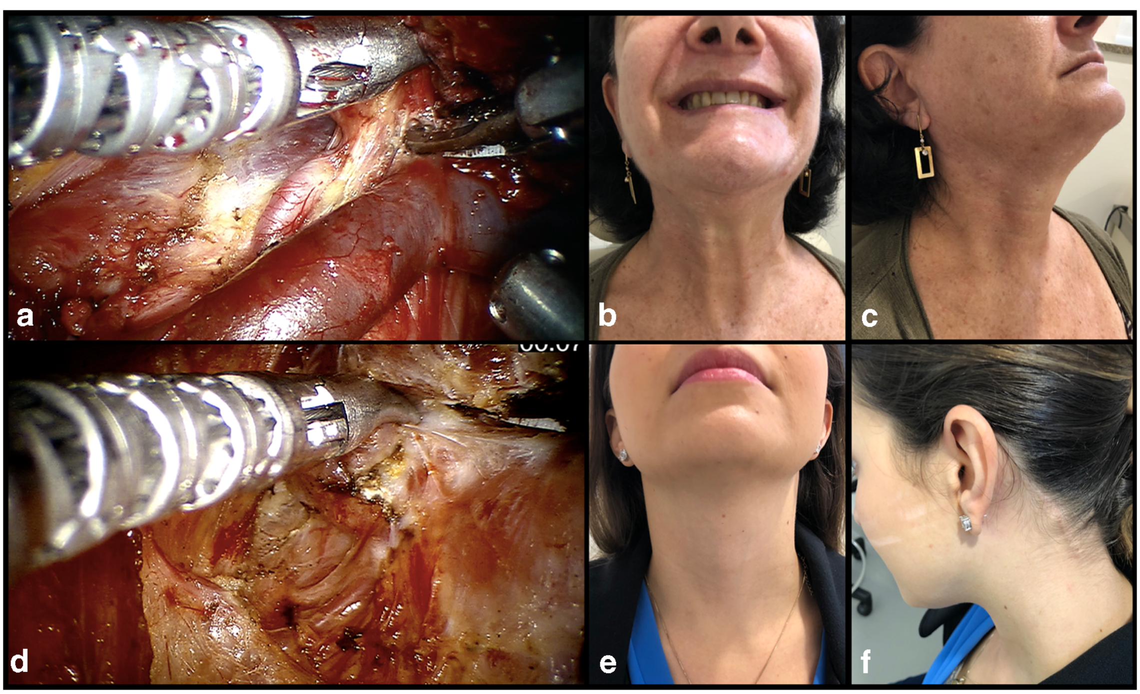

Fig. 1 **a** Console view during robotic neck dissection. **b**–**c** Post-operative neck appearance following robotic selective neck dissection of levels I–III using retroauricular approach. **d** Console view during robotic thyroidectomy via retroauricular approach. **e** and **f** Post-operative neck appearance following robotic left hemithyroidectomy via retroauricular approach

robotic surgery will be made of technological evolution and, hopefully, increasing accessibility. With more suited and more equipped robotic systems, robotic-assisted procedures could improve multiple areas of HNS and oncology. Simultaneously, we the surgeons must face several obstacles to help this evolution, tackling the lack of objective data on functional outcomes and prospective surgical/oncological outcomes and promoting more appropriate training smoothing the learning curve of our fellows and residents.

Compliance with Ethical Standards

Conflict of Interest None of the authors has any potential conflicts of interest to disclose.

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