10 Robotic Thyroidectomy

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10.1 Introduction

It was in the nineteenth century when Kocher developed and refined the classical cervical thyroidectomy; however, it has remained almost unchanged since [1]. The cervical approach has been proven as highly reliable and relatively fast but unfortunately leaves an obvious scar in the anterior cervical region. In recent years, advances in surgical instrumentation have introduced the minimally invasive thyroid surgery. The endoscopic thyroid surgery, popularized by Miccoli from Italy (the minimally invasive video-assisted thyroidectomy (MIVAT)), resulted in less morbidity and smaller surgical scars [2]. However, the endoscopic cervical approach is relatively challenging due to the use of straight and rigid instruments with no articulations. Moreover, the neck is a very confined space to use CO_2 insufflation, with risk of $PaCO_2$ elevation, subcutaneous emphysema, and air embolism [3].

The non-cervical, remote-access approaches were developed primarily due to cosmetic concerns and unfavorable scarring, particularly in certain ethnic groups, and the aversion to neck scars in the Asian culture [4]. The transaxillary endoscopic thyroidectomy was first introduced by Ikeda et al. in 2000 [5].

With the introduction of the da Vinci robot (Intuitive Surgical, Sunnyvale, CA, USA), surgeons have implemented its advantages to thyroid surgery. In late 2007, Chung and his team from Seoul started implementing the robotic-assisted transaxillary thyroid surgery (RATS) and introduced it in 2009 [6, 7]. This approach was described later, in 2011 in the USA, by Kuppersmith and Holsinger, where body habitus is considerably different than that of the Asian population [8]. Originally, the RATS was performed with two incisions (axillary and anterior chest wall), but later a modification using only a single axillary incision was described [5]. Since 2008, thousands of RATS procedures have been performed worldwide, almost half of those in South Korea [9]. Among the other robot-assisted thyroidectomy (RT) approaches, the transaxillary became the most popular.

Since the RATS was introduced, it has gained much interest worldwide with several teams publishing their initial successful experience [10]. However, since the conventional approach has long been proven to be safe and effective, some surgeons are hesitant regarding the clinical use of robotic thyroid surgery [11]. Robotic thyroidectomy remains controversial, especially in North America, where the FDA has revoked the approval on robotic thyroidectomy in 2011 [10].

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Z. Gil et al. (eds.), *Atlas of Head and Neck Robotic Surgery*, DOI 10.1007/978-3-319-49578-1_10

Several criteria for candidates to RATS were described, but there are no standard selection criteria [12]. Recommended absolute contraindications are previous neck surgery or radiation, retrosternal thyroid extension, and advanced thyroid disease (invasion of the trachea, esophagus, distant metastases). Relative contraindications include patient comorbidities, advanced age, obesity, very large goiters, well-differentiated carcinomas with a diameter larger than 2 cm, lateral neck metastases, and known ipsilateral shoulder dysfunction [5, 13, 14].

During the same period the RATS was introduced, multiple other remote-access robot-assisted thyroidectomy approaches were described. This chapter will discuss the more widely described RATS approach.

10.2 Transaxillary Approach: Surgical Technique

The RATS can be divided into three surgical stages

10.2.1 Working Space

The surgery is performed under general anesthesia. The use of an endotracheal tube with laryngeal nerve monitoring is recommended.

The dissection area is outlined by anatomical landmarks. The axillary incision is defined in its inferior border by a horizontal line, from the sternal notch, and the superior border—by an oblique line—at a 60° angle from the thyroid notch. The incision itself is performed in the anterior axillary line (Fig. 10.1).

The axillary incision may be marked, while the patient is sitting, with the arms relaxed in a neutral position, to verify it is well camouflaged.

Following anesthesia, the patient is placed in a supine position with the neck mildly extended. The patient's arm is placed in an extended position over the forehead, with the elbow flexed at 90° (Fig. 10.1). The arm should be carefully rotated and padded. Eye protection should be applied to avoid any injuries from the robotic arms during surgery.

Following the axillary incision (5–6 cm), a subcutaneous dissection is performed and carried superficial to the pectoralis major muscle, to the direction of the clavicle. At the sternoclavicular joint, the sternal and clavicular heads of the sternocleidomastoid muscle are identified. The dissection then continues between these two heads, at which point the strap muscles are identified and deeper to it, the thyroid gland. Care should be taken during this step to avoid injury to the internal and external jugular veins. At this point, a retractor is inserted to elevate the skin flap, thereby creating a tunnel from the axilla to the thyroid gland (Fig. 10.2).

10.2.2 Docking of the Robot

The da Vinci cart is positioned in the contralateral side, while the robotic arms extend over the patient. The three arms and the camera are inserted through the axillary incision and along the working space

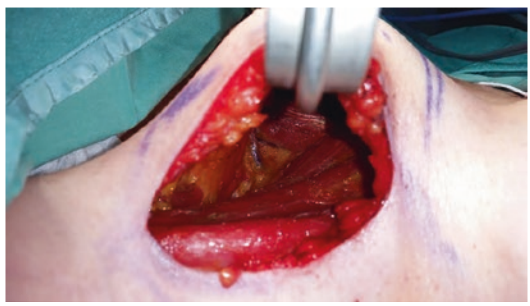

Fig. 10.2 View of working space after retractor insertion

Fig. 10.1 Ipsilateral hand position: extended over the forehead, elbow flexed at 90°

(ProGrasp forceps, harmonic shears, and Maryland dissector). The correct alignment of the robotic arms within the tunnel is crucial to avoid collision of the robotic arms inside the working space, during the console time. The recommended alignment of the robotic arms is with the forceps used for retraction at the top of the working space, the Harmonic scalpel (Harmonic ACE® curved shears) on the inferior cephalad side, the dissector on the inferior caudal, and the camera in the middle inferior of the surgical field. The assistant may further retract the strap muscles using the suction catheter.

10.2.3 Robotic Thyroidectomy (Console Time, Figs. 10.3–10.10)

The thyroidectomy is performed in the classical order: first, dissecting the superior pole off the cricothyroid muscle, using the harmonic shears, and safely transecting the superior thyroid vessels close to the gland as to avoid external branch of SLN injury; second, the thyroid lobe is retracted medially in order to expose the parathyroid glands and the recurrent laryngeal nerve (RLN). After ligating the inferior thyroid vessels and identifying the trachea, further mobilization is achieved, and further medial dissection is carried out while carefully preserving the RLN. The lobe is carefully dissected from Berry's ligament and extracted through the axillary incision. Saline irrigations may assist in preventing thermal injury to the RLN from the harmonic shears. A clip demonstrating the robotic hemithyroidectomy is attached.

A total thyroidectomy is performed via the same axillary incision used for the ipsilateral lobe. The decision regarding which lobe to dissect first should not differ from the cervical approach where the surgeon would usually favor resecting the larger lobe or nodule side first. The axillary incision should be performed ipsilateral to that lobe, and the resection should be carried out in the same fashion detailed above, before attempting to resect the contralateral lobe. After the extraction of the ipsilateral lobe, the assistant should retract the trachea downward, while the superior pole of the contralateral lobe is retracted upward using the ProGrasp forceps. The deep aspect of the lobe is then dissected away from the trachea using the harmonic shears. It should be noted that the contralateral RLN is not easily visible as is the ipsilateral one so care must be taken to avoid injury.

Some surgeons advocate removing the thyroid with an endo-bag as to avoid any tissue spillage. Lastly, a drain is placed in the thyroid bed [12, 15].

10.2.4 Advantages of RATS

The most considerable advantage of RATS over conventional cervical thyroidectomy is that it avoids any cervical incision. This cosmetic aspect makes RATS appealing especially to young female patients, which is the majority of the patient population, and those with a tendency toward keloid or hypertrophic scar formation. An example of an axillary scar can be seen in Fig. 10.3.

Fig. 10.3 Postoperative axillary scar (Contributed by Dr. Patrick Aidan, The American Hospital in Paris, France)

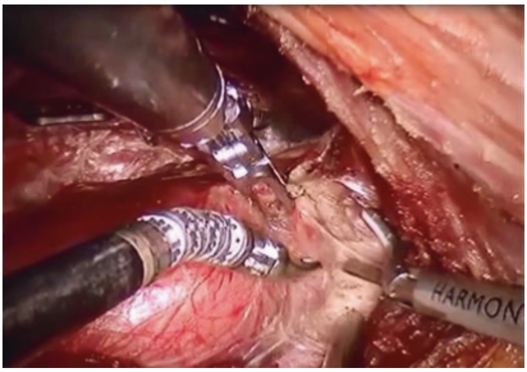

Fig. 10.4 Dissection of the superior pole of the thyroid lobe with the harmonic scalpel. General view (landmarks): left thyroid lobe, trachea, internal jogular vein (blue hue at the bottom), Omohyoid muscle retracted at the right and bottom of photo, Cricothyroid muscle at the top right

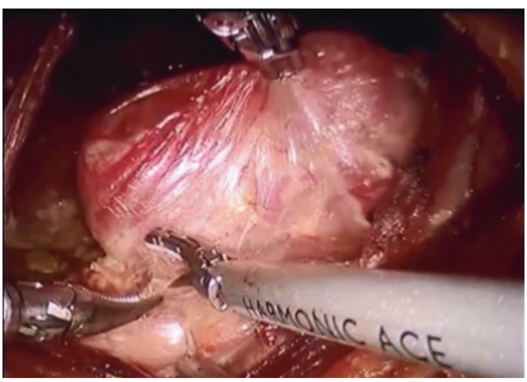

Fig. 10.5 Dissection of the inferior pole of the thyroid lobe with the harmonic scalpel while lobe is retracted upwards by the prograsp

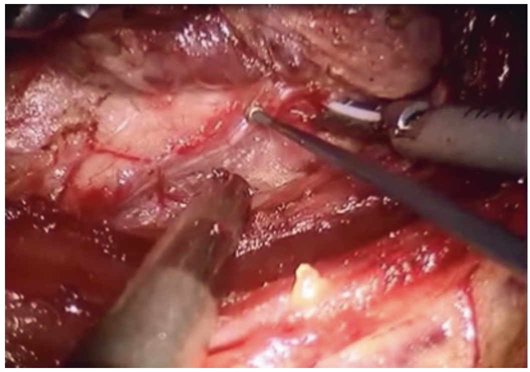

Fig. 10.6 RLN is visible and stimulated by the nerve stimulator for verification

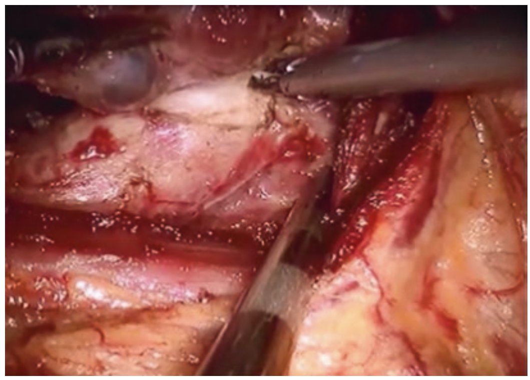

Fig. 10.7 Once the RLN has been identified, carefull dissection of the thyroid lobe off the trachea is performed using the harmonic scalpel

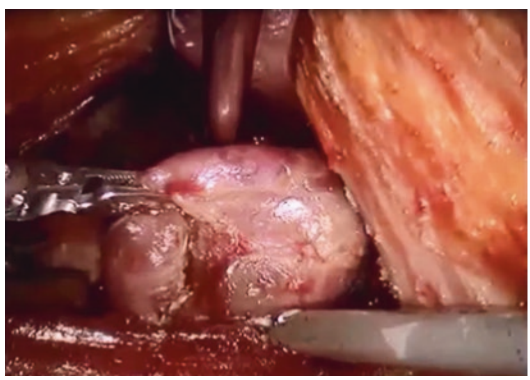

Fig. 10.8 Separating the isthmus

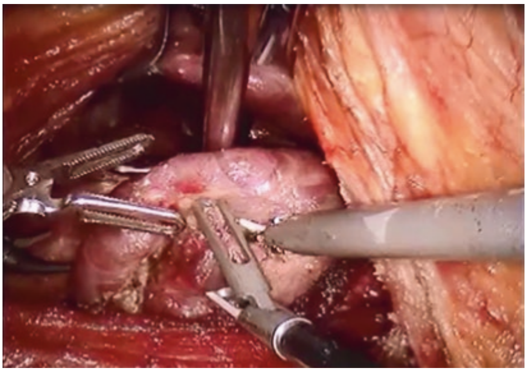

Fig. 10.9 The disconnected lobe is removed through the axilla

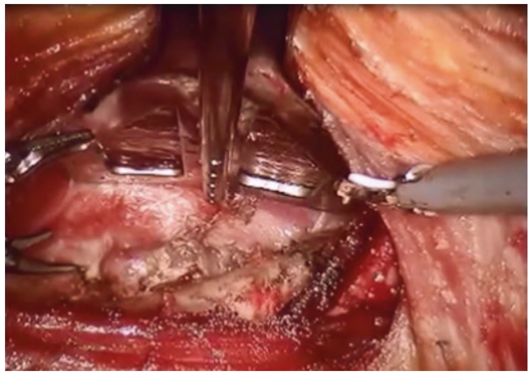

Fig. 10.10 View s/p hemithyroidectomy: trachea and isthmus of contralateral lobe

The RATS has some major technical advantages. First, the robotic camera provides three-dimensional high-resolution visualization, which enables an easier identification of the RLN and parathyroid glands compared to the cervical approach; second, the robotic arms eliminate the natural surgeon tremor; and, third, it provides a wider range of motion through the robot's EndoWrist and the articulations of the arms. In addition, the improved visualization and surgical ergonomics have been reported to reduce musculoskeletal discomfort to the surgeon compared with open or endoscopic surgery [7].

Lastly, with regard to patients' quality of life, RATS was found to yield better patient outcomes, including reduced pain and increased cosmetic satisfaction, as well as lower rates of paresthesia over the neck, postoperative voice change, and swallowing discomfort [16, 17].

10.2.5 Disadvantages of RATS

This relative new approach to the thyroid gland, in terms of the surrounding anatomy and the loss of tactile sensation, may expose the patient to potential new complications such as tracheal, esophageal, or brachial plexus injury. Very few studies accounted for such complications, with minimal attention to the conversion rate to open thyroidectomy. Due to the ipsilateral arm position, there is a risk of brachial plexus neuropathy. This risk can be reduced by placing the arm in a flexed overhead 90° position, thereby reducing the chance of stretching the nerves. Care must be taken to avoid local pressure from the robotic arm. Intraoperative neurophysiological monitoring of the ulnar, radial, and median nerves may further reduce the possibility of brachial plexus injury, by identification of any impending damage to these nerves and enabling the patient to be repositioned as needed [18]. Intraoperative monitoring has shown to decrease rates of hypoesthesia and pain and improve shoulder movement, as well as higher quality of life, in the early postoperative period [19]. Despite the benefits of intraoperative monitoring, it is not obligatory in RATS.

Another disadvantage of RATS is the longer operative time mainly due to the extra time needed for the creation of the working space and the robot docking. In different studies, it is assessed as 1.5–3 times compared to the cervical approach. However, several studies have examined the learning curves of the RT and have shown that increased experience led to decreased total operative time [1]. RATS involves a relatively challenging learning curve, compared to the conventional approach. However, it has been demonstrated that RT required 35–40 procedures, much lower compared to the endoscopic approach [7]. Park et al. examined the learning curves of surgeons with little or no experience, performing transaxillary RT on 125 patients. They showed excellent results compared to those in a larger series of more experienced surgeons and, specifically, that the operation times gradually decreased, reaching a plateau after 20 procedures [20]. Another disadvantage of RATS is the limitation in the body habitus and BMI. With RATS, the working space dissection is relatively more challenging in obese patients (BMI >30). However, it has been demonstrated, and per the authors' experience, that in skilled hands, the body habitus limitation is irrelevant [21, 22].

In terms of economic considerations, RT is a more expensive procedure compared to open thyroidectomy, primarily due to the cost of the equipment (da Vinci robot itself and periodic maintenance of the robotic arms), staff training, and longer operative time. However, RT actually eliminates the need for an additional surgical assistant, and, combined with the potentially shorter hospital stay and the expected decrease in the maintenance cost of the robot, this may lower the costs of the procedure.

10.3 RATS Experience

RATS is being practiced mainly in South Korea and Asia and, to a smaller extent, in Europe and North America. With the rising popularity of RT, several meta-analyses were conducted in order to examine both the surgical and oncological safety of RT compared to conventional and endoscopic approaches.

In 2015, Kandil et al. summarized 18 studies, including 4878 patients, and concluded that RT was associated with longer total operative time (mean difference 43 min) and had similar risks of total postoperative complications and similar oncological results [23].

Another meta-analysis published in 2014 by Jackson et al. [1] summarized a total of nine studies with 2881 patients, 1122 of whom underwent RT. They conclude that RT is as effective as endoscopic and open thyroidectomy, with equivalent postoperative results, shorter hospitalization, and higher patient satisfaction. Several other meta-analyses with overall 1000–3000 patients demonstrated similar results, in addition to lower blood loss and lower level of swallowing impairment [16, 24–26].

Lee et al. have also published their experience with 2014 patients who underwent RATS, with a low complication rate of 1% for major complications (e.g., permanent RLN or brachial injury, conversion to open thyroidectomy) and 19% for minor ones (transient hypocalcemia, seroma, etc.). Interestingly, this group also found that in terms of the surgeon's musculoskeletal ergonomic parameters, RATS resulted in less neck and back discomfort than did the endoscopic or open thyroidectomy [7].

One of the relative contraindications of RATS is Graves' disease, due to the usually large-volume thyroid glands and hypervascularity. However, some surgeons have already reported their successful experience with Graves' patients showing similar complication rates, blood loss, and hospital stay [27, 28]. The largest European experience from Paris, France, with over 350 robotic thyroidectomies and neck dissections, is also very promising with low complication rates. Interestingly, almost 60% of their RT involved large-volume thyroid glands (over 20 mL) [29]. It should be noted that all patients received potassium iodide preoperatively.

In skillful hands, RATS can be feasible and safe for patients with large-volume thyroid glands such as Graves' and MNG patients.

10.4 RATS in Papillary Thyroid Carcinoma

The incidence of thyroid cancer is gradually increasing worldwide, and in accordance with that, the proportion of papillary thyroid microcarcinomas. Since early-stage PTC has an excellent prognosis with minimal mortality and low recurrence rates, the patients' quality of life issues, including cosmetic concerns, play a major role [9, 19].

In 2011, Lee et al. published their experience with RT on 1043 patients with low-risk well-differentiated thyroid carcinoma. They showed that the RATS was feasible and offered outcomes similar to conventional and endoscopic thyroidectomies [30]. Another study published recently explored the efficacy of RATS in North American population with thyroid cancer, compared to the conventional approach—they found similar operative times and blood loss, with negative margins for malignancy and similar thyroglobulin levels [3].

Ban et al. have described the surgical complications in their experience of 3000 patients who underwent RT for thyroid cancer. Hypocalcemia was the most common complication, 1% permanent; permanent RLN injury, 0.27%; tracheal injury, 0.2%; carotid artery injury, 0.03%; skin flap injury, 0.1%; and brachial plexopathy, 0.13%. The mortality rate was 0% [31]. Male gender, overweight BMI, a large thyroid gland, and coexistent thyroiditis are factors that were found to adversely affect the surgical outcome of RT in DTC cases, namely, longer operative times [9].

The resection of the contralateral thyroid lobe in total thyroidectomy is surgically challenging via a single axillary incision. Therefore some surgeons doubted the surgical completeness of the procedure. A recently published meta-analysis compared the surgical completeness and oncological outcome between RT and conventional open thyroidectomy (OT) in low-risk DTC. Ten studies were analyzed, including 752 patients who had RT and 1453 patients who had OT. RT was associated with fewer central lymph nodes retrieval and less-complete resection (based on Tg levels), compared to OT, probably due to residual tissue in the contralateral side. Nevertheless, no locoregional recurrence was found in the RT group; therefore, the authors concluded that using RT was unlikely to compromise the outcomes of low-risk DTC [10]. Other studies and meta-analyses investigated the completeness of the thyroidectomy, comparing it to conventional thyroidectomy using stimulated thyroglobulin levels, RAI uptake, and postoperative sonography. These studies ultimately demonstrated that the surgical completeness of RT is comparable to conventional thyroidectomy, if performed by experienced surgeons [32–36].

Some criticism arose regarding the oncological assessment of RT in thyroid cancer due to the relatively short follow-up period in most studies, compared to the long-term risk of recurrence in these tumors. In addition, some argued against bias as the RT procedures were performed mainly for microcarcinomas and other early-stage thyroid cancers. To address these issues, the South Korean team recently compared longer-term oncologic outcomes (over 5 years after surgery), in patients who underwent robotic (245 patients) or conventional total thyroidectomy (494 patients) and central neck dissection for PTC. To avoid selection bias, the groups were matched for age, gender, tumor size, extrathyroidal invasion, multiplicity, bilaterality, and TNM stage. They found similar serum thyroglobulin (Tg) and anti-thyroglobulin antibody (TgAb) levels. Nine patients experienced locoregional recurrence, six in the conventional group and three in the robotic group, with all recurrences in regional LNs. Disease-free survival was similar [37].

A newly reported use of the RATS for modified radical neck dissection (MRND) suggests that the precise movements and magnified 3D vision enable a meticulous and safe dissection with recovery of similar numbers of lymph nodes as an open procedure with similar recovery of neck and shoulder disability [35, 38].

10.5 Other Robotic Thyroidectomy Approaches

Alternate robotic remote-access thyroidectomy approaches were also described in recent years. These included the bilateral axillo-breast approach (BABA), currently performed mainly in Korea with successful outcome [39]; transoral and infraclavicular approaches, with very limited experience in humans [40, 41]; and the facelift approaches.

The robotic facelift, or retroauricular thyroidectomy, was first introduced by Terris in 2011. It was developed to overcome the concerns and complications of robotic axillary thyroidectomy, namely, brachial plexus injury and anterior chest wall discomfort, and to adjust the procedure to the western population. It presents a growing body of evidence supporting its feasibility and safety [42, 43].

Conclusions

RATS has gained much popularity in recent years, mainly in Asia and Europe. It is considered an oncologically and surgically safe alternative to cervical thyroidectomy, with increased patient satisfaction. RATS should be performed in high-volume centers, by skilled surgeons, and presented to suitable patients, especially those with aesthetic concerns; with increasing experience and improvement in the robotic technology, the indications for RATs will continue to expand.

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