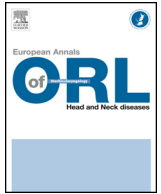




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Technical note

Robot-assisted transaxillary thyroidectomy: Surgical technique



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ARTICLE INFO

Keywords:
 Robotic
 Thyroidectomy
 Transaxillary
 Robot-assisted surgery

ABSTRACT

Robot-assisted transaxillary thyroid surgery avoids the need for a neck incision. It consists of thyroid lobectomy and isthmectomy for moderately large unilateral benign nodules. The surgical imperatives are the same as for conventional surgery, but with differences in terms of patient positioning, surgical incision, equipment, surgical technique and indications. The purpose of this article is to describe the equipment, patient positioning and surgical technique of exclusive robot-assisted transaxillary total thyroid lobectomy and isthmectomy.

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1. Introduction

Thyroidectomy, without a visible scar, represents a surgical challenge corresponding to a legitimate request expressed by the patient. One of the proposed approaches is to perform an axillary incision. This procedure has become very popular with the development of the Da Vinci robot (Intuitive Surgical Inc., CA), which improves the precision and surgical comfort compared to the non-robotic transaxillary endoscopic technique. More than 6000 robot-assisted thyroidectomies were performed in Korea between 2007 and 2011 [1], mainly total thyroidectomies with central compartment lymph node dissection for cT1N0 papillary carcinomas. Korean series report similar complications and oncological results to those of conventional surgery [2].

Surgical imperatives (functional preservation of the recurrent laryngeal nerve [RLN] and parathyroid glands) are the same as in conventional surgery, but with differences in terms of patient positioning, equipment and surgical technique. A protocol clearly defining the procedure and patient selection criteria is therefore essential. The authors describe the surgical technique based on a series of 26 cases of exclusive robot-assisted transaxillary thyroid surgery (RATS) (lobectomies and isthmectomies) performed for benign nodules.

2. Surgical technique

2.1. Patient positioning

The patient is intubated with an endotracheal tube comprising recurrent laryngeal nerve (RLN) monitoring (NIM 3.0 Medtronic, MN), and placed in the supine position with moderate Rose position (Fig. 1a). The arm on the side of the lobe to be operated is placed above the head, without exceeding 125° of antepulsion, with the elbow flexed to 90° and with the forearm over the forehead supported in a hammock with protective gel by an inverted bracket attached to the table on the opposite side to the incision; a bolster placed underneath the ipsilateral shoulder, and the contralateral arm left alongside the body.

2.2. Axillary incision and creation of the working space

The incision is performed by “direct” surgery. Landmarks are marked with a skin marker pen (Fig. 1b). Sterile drapes include the axillary, anterior cervical and prepectoral regions, allowing surveillance of skin integrity during the incision and possible conversion to anterior neck surgery.

The skin incision, 6 to 9 cm long according to the patient's morphotype and the size of the thyroid nodule, is extended as far as the pectoralis fascia. The surgical assistant, opposite the operator, retracts the tissues with Farabeuf retractors. Dissection is performed with an electrical scalpel in the prepectoral fascia as far as the sternocleidomastoid (SCM) muscle and thyroid gland. The increasing depth of the dissection tunnel requires long instruments (20 to 30 cm) and a vaginal retraction valve. The lesser

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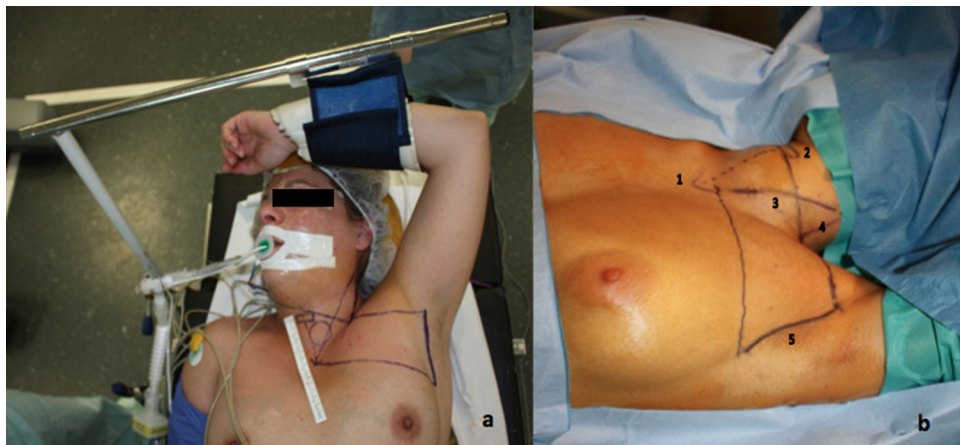


Fig. 1. Patient positioning (a) and anatomical landmarks (b): a: exposure of the axilla by extension of the shoulder and flexion of the elbow to 90° to achieve the shortest distance between the axilla and the thyroid gland; b: sternal notch (1), inferior margin of the cricoid cartilage (2) and superior pole of the thyroid lobe when palpable, anterior (3) and posterior (4) margins of the sternocleidomastoid muscle and midline. Two transverse lines are drawn from the sternal notch and inferior margin of the cricoid cartilage to the midaxillary line. Their intersections with the midaxillary line define the limits of the axillary incision (5). These lines delineate the dissection corridor of the incision. The italic S-shaped incision in the midaxillary line must be hidden in the axilla when the arm is in the neutral position, and measures 6 to 8 cm.

supraclavicular fossa between the sternal and clavicular heads of the SCM muscle is used. The internal jugular vein is preserved posteriorly. A small or large endoscopic clip applier (Ligaclip, Ethicon Endosurgery) can be used to control afferent veins. The strap muscles are released from the anterior surface of the thyroid lobe over a distance ranging from the sternal notch to the superior pole of the thyroid lobe, thereby creating the working space. A Chung retractor (Biorobotics, Korea), attached to the table on the opposite side to the incision, retracts the sternal head of the SCM muscle and the strap muscles. The Chung retractor passes over the patient's contralateral shoulder from the incision to the working space (Fig. 2).

2.3. Positioning of the robot

The Da Vinci® Si-HD surgical robot (Intuitive Surgical Inc.) consists of a surgeon console that controls the instrument holder on the

patient side and a high definition telemonitoring screen. The four arms of the robot carry: a 12 mm 30° endoscope directed downwards, Maryland dissecting forceps, Prograsp fenestrated forceps, Ultracision harmonic scalpel (Ethicon Endosurgery, GA).

The sterile draped robot is advanced to the patient's head, on the side opposite to the incision in the axis of the Chung retractor. The position of the camera and instruments in the axillary single incision is defined in order to allow maximum mobility and to prevent instrument conflicts: camera directed upwards with respect to the floor (20° to 30°) and the patient's feet (10° to 20°), Maryland and Ultracision harmonic scalpel placed on either side of the camera and directed towards the floor with a craniad direction for the instrument on the caudad side of the incision (Ultracision harmonic scalpel for a right-sided procedure) and a caudad direction for the instrument on the cranial side. These two instruments and the camera form an equilateral pyramid with a summit situated

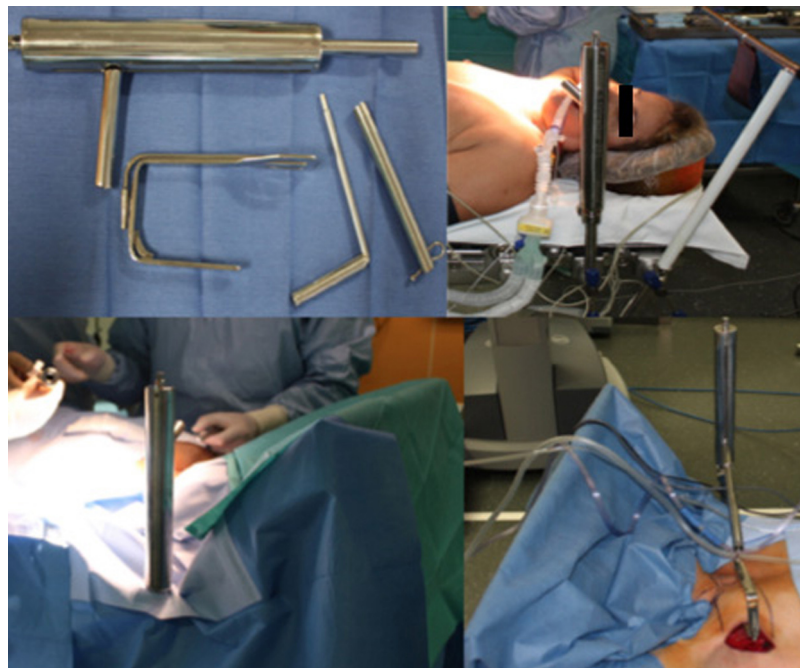


Fig. 2. Exposure of the working space using the Chung retractor. Exposure of the working space using the Chung retractor (Biorobotics, Korea) attached to the table on the opposite side to the incision, passing over the patient's shoulder and angled towards the thyroid to retract the sternal head of the SCM muscle and the strap muscles.



Fig. 3. Operating position of the robot (right-sided procedure). Triangulation of the main instruments: camera, Maryland (arm 2) and Ultracision (arm 3). The Prograsp forceps (arm 1) is positioned between the endoscope and the instrument at the caudal extremity of the incision.

in the working space (Fig. 3). The centre of the instrument wagon, the Chung retractor, the thyroid and the camera are all situated in the same plane. The Prograsp forceps is positioned between the endoscope and the instrument on the caudal side.

2.4. Robot-assisted resection of the thyroid lobe

The surgeon operates the console and the assistant and scrub nurse are placed next to the patient to ensure the absence of any conflict of the robotic arms. The assistant aspirates smoke, retracts tissues, irrigates and introduces instruments into the operative field. The Prograsp fenestrated forceps is used to retract the thyroid lobe, while the Maryland forceps and Ultracision harmonic scalpel are used for dissection. The Ultracision is used to coagulate and section blood vessels. Dissection, in contact with the capsule to avoid damage to the superior and recurrent laryngeal nerves and parathyroid glands, starts with the most accessible thyroid pole, often the superior pole; the Prograsp forceps is used to retract the lobe inferiorly and medially, while the Ultracision is used to release the superior pole. Parathyroid glands are identified and preserved. The middle thyroid vein is coagulated and sectioned. The inferior pole of the lobe is dissected and released, allowing “conventional” surgery with retraction of the medial lobe. The inferior thyroid artery and RLN are identified (Fig. 4). The RLN is stimulated at 0.5 mA and dissected as far as its penetration into the larynx. A neurosurgical swab is placed over the RLN to protect it from the heat of the Ultracision scalpel. The inferior thyroid artery is ligated,

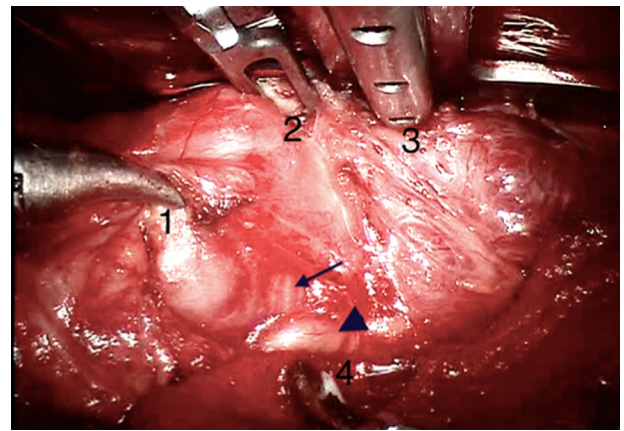


Fig. 4. Endoscopic view of robot-assisted transaxillary left thyroid lobectomy and isthmectomy. 1: Maryland forceps; 2: Prograsp forceps; 3: Chung retractor; 4: Ultracision; Arrow: inferior thyroid artery; arrowhead: recurrent laryngeal nerve.

using the Ultracision scalpel, in contact with the thyroid lobe. Isthmectomy is then performed. Finally, the functional integrity of the RLN is checked by a nerve stimulator introduced by the assistant using long endoscopy forceps and is then grasped and manipulated by Maryland forceps.

Two 10 F suction drains are placed in the prepectoral dissection space and are brought out behind the wound, and are removed on the second day. The wound is closed in 2 layers with subcutaneous 3.0 resorbable suture material and a resorbable 4.0 monofilament intradermal running suture. A pectoral compressive dressing is applied for 48 hours. The resection specimen is sent to the pathology department for definitive histological examination.

In our series, histological examination revealed two cases of pT2 follicular variant of papillary carcinoma requiring secondary contralateral transaxillary total thyroidectomy. No lymph node dissection was performed in the absence of any clinical or ultrasound evidence of lymphadenopathy (cN0).

At the end of operation, the anaesthesia team performed ultrasound-guided local anaesthesia by intermediate cervical (superficial and deep cervical plexus) and pectoral block with Naropine® (ropivacaine). Analgesic consumption was not different from that observed after conventional surgery.

All patients were discharged from hospital on the second postoperative day except for the patient who required total thyroidectomy on the fourth day (postoperative hypocalcaemia).

The mean total operating time was 157 minutes (incision: 30 min, robot installation: 15 minutes, robot-assisted thyroid lobectomy: 105 minutes) and decreased significantly after the 6th procedure. A detailed analysis of the learning curve is presented in another publication.

3. Discussion

Robot-assisted transaxillary thyroid lobectomy and isthmectomy avoids a visible neck scar and decreases postoperative discomfort, swallowing difficulties and neck skin sensory loss. The technique appears to be feasible under satisfactory conditions of safety for carefully selected patients who request this type of surgery to avoid a neck scar, especially when they have a history of keloid scars. This type of surgery is indicated for nodules with no suspicion of malignancy (clinical evaluation, ultrasound and aspiration cytology with Bethesda grade <4). Nodules must be <5 cm in diameter, situated in a lobe <7 cm in the absence of plunging goitre. Patients with a short distance between the sternal notch and lateral edge of the pectoralis major muscle, a low BMI, and slight musculature are the best candidates.

According to the literature, the contraindications are: distance between the sternal notch and lateral edge of the pectoralis major muscle > 18 cm and BMI > 30 kg/m² (relative); plunging or very large goitre with posterior extension along the trachea and oesophagus (risk of tracheal or oesophageal or RLN injury), pre-existing shoulder disease, history of neck and pectoral surgery or irradiation, thyroiditis (absolute) [3].

This type of surgery presents a number of disadvantages:

- Ryu et al. [2] reported permanent recurrent laryngeal nerve paralysis in 0.8% of cases and transient recurrent laryngeal nerve paralysis in 4.7% of cases. No case of permanent recurrent laryngeal nerve paralysis was observed in our series, but the rate of transient recurrent laryngeal nerve paralysis was higher than that observed after conventional surgery (23% versus 5% in our series of open procedures), with no visible trauma to the recurrent laryngeal nerve and despite nerve monitoring, which is considered to be essential [4]. These injuries can be attributed to the Ultracision harmonic scalpel (diffusion of heat to the nerve) or direct nerve injury because, although the vision and precision of the procedure are very similar to those of open surgery, the robotic system does not provide the same tactile feedback. The Ultracision harmonic scalpel can be replaced by bipolar forceps (Endowrist, Intuitive Surgery, CA), by inverting the introducer trocars which are of different calibres;
- all patients experienced transient prepectoral dysaesthesia. One patient also required conversion to open surgery due to a very large plunging goitre, and 2 cases of postoperative seroma were observed. Serious complications have been reported in the literature: brachial plexus palsy, which appears to depend on patient positioning and operating time [5], tracheal effraction [6], internal jugular vein injury that may require conversion to a conventional neck incision [7]. Friction of instruments or heat transmitted by the Ultracision may be responsible for these complications and we have sometimes used a malleable plate placed over the jugular vein. Some teams perform preoperative ultrasound to assess the calibre and position of the internal jugular vein in order to determine the feasibility of the procedure [8];
- this type of surgery requires a longer operating time, which decreases with experience [2];
- this type of surgery is expensive: acquisition of the robot, maintenance, and consumable items: €1,195 per procedure (Maryland forceps: €230, Ultracision harmonic scalpel: €485, Prograsp forceps: €220, robot draping kit: €260), versus €280 for an open surgery harmonic scalpel;
- several teams perform a second subareolar or parasternal incision to reduce instrument conflicts [2]. A single axillary incision improves the cosmetic result, makes the procedure less invasive and limits interference with subsequent mammographies or surgery in this region [9]. Instrument conflicts can be limited by clearly defining the incision, creation of the working space, and positioning of the robot, together with intraoperative surveillance by the assistant [3,10]. As the Ultracision harmonic scalpel

is not articulated, certain degrees of freedom are not authorized and certain operative regions may therefore be difficult to access. It is therefore useful to interchange this instrument with Maryland forceps during the operation to obtain a more favourable angle [3,9];

- satisfactory conduct of the operation depends on creation of the working space. The minimal incision is 6 cm [6] and dissection must ascend sufficiently high to control the superior thyroid pedicle. Dissection must be continued as far as the cricoid, or sometimes higher in the case of a superior pole nodule and an abnormally high thyroid. Some teams continue dissection as far as the thyrohyoid membrane [8], but this technique does not appear to be systematically justified. A distance of 4 cm between the anterior and posterior limits of the incision, and a space ≥ 1 cm between the anterior surface of the thyroid and the Chung retractor are recommended.

4. Conclusion

RATS is a feasible technique avoiding a neck scar. The essential challenge raised by this technique is to allow surgery without excessive conflicts or limitations of movements. When these conditions are met, RATS allows lobectomy similar to that performed via conventional open thyroid surgery. A multicentre, prospective, comparative trial needs to be conducted to evaluate the benefit-risk balance and excess cost related to this innovative technique.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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