Surgical Oncology 28 (2019) 9–13

Contents lists available at ScienceDirect

Surgical Oncology

journal homepage: www.elsevier.com/locate/suronc

First report of *in-situ* preservation of a subcapsular parathyroid gland through super-meticulous capsular dissection during robotic radical thyroidectomy

Xiaowei Qi, Junze Du, Haoxi Liu, Xiang Cui, Yanling Li, Wenying Fu, Jun Jiang, Linjun Fan*

Breast and Thyroid Surgery, Southwest Hospital, Third Military Medical University, Chongqing, 400038, China

ARTICLE INFO

Keywords:
In-situ preservation
Subcapsular parathyroid gland
Super-meticulous capsular dissection
Robotic surgery

ABSTRACT

Purpose: Meticulous capsular dissection can preserve the function of the parathyroid gland in most patients, but it is difficult to identify and preserve the subcapsular parathyroid gland. We performed *in-situ* preservation of the subcapsular parathyroid gland during robotic radical thyroidectomy using super-meticulous capsular dissection, and evaluated its effect on postoperative parathyroid function.

Methods: A 45-year-old woman was admitted with bilateral thyroid nodules. Color Doppler ultrasound demonstrated a 7 × 7 × 6 mm hypoechoic area in the middle and inferior part of the right lobe and 3 × 3 × 3 mm hypoechoic nodule in the middle part of the left lobe. She was diagnosed with right thyroid papillary cancer by fine-needle aspiration. Robotic bilateral thyroidectomy plus right central lymph node dissection was performed. During the left thyroidectomy, we found that the left inferior parathyroid gland was just under the true capsule. Subsequently, the super-meticulous capsular dissection was performed for *in-situ* preservation of the parathyroid gland.

Results: The patient's serum parathyroid hormone concentration was 43.77 pg/ml before and 37.98 pg/ml after surgery (normal: 15–65 pg/ml). Her blood calcium level was 2.21 mmol/l before and 2.18 mol/l after surgery (normal: 2.10–2.65 mmol/l).

Conclusions: The super-meticulous capsular dissection, which could cut through the true capsule to identify subcapsular parathyroid and protect its anatomic structure as well as blood supply, is recommend for *in-situ* preservation of subcapsular parathyroid gland during robotic radical thyroidectomy.

1. Introduction

Hypoparathyroidism is a common complication after thyroidectomy, in which the removal of or interruption of the blood supply to the parathyroid gland during thyroidectomy leads to a postoperative decrease in parathyroid hormone (PTH) concentration and, consequently, a decrease in serum calcium, with deleterious effects on patients' postoperative quality of life [1]. Meticulous capsular dissection can preserve the function of the parathyroid gland in most patients [2]; however, as a result of variation in its location, the parathyroid gland is difficult to identify and preserve *in situ* using the conventional surgical techniques especially when it is situated within the thyroid parenchyma or just under the true capsule [3]. In this paper, we performed *in-situ* preservation of subcapsular parathyroid gland during robotic radical thyroidectomy through super-meticulous capsular dissection and observed no significant decrease in postoperative parathyroid function.

2. Methods

2.1. Clinical data

A 45-year-old woman was admitted on Day 15 for bilateral thyroid nodules discovered in a physical examination. A physical assessment found no palpable mass in the anterior cervical area and no enlarged lymph nodes in the bilateral cervical regions. Color Doppler ultrasound identified a 7 × 7 × 6 mm hypoechoic area in the middle and inferior part of the right lobe, with an unclear border and dot- or line-like blood flow signals inside. It also revealed 3 × 3 × 3 mm hypoechoic nodule in the middle part of the left lobe. They were both classified as Thyroid Imaging Reporting and Data System category 4b (Fig. 1). The bilateral cervical lymph nodes were normal in size and shape. Owing to the nodule of the left lobe smaller than 5 mm in diameter, fine-needle aspiration was only performed for the nodule of the right lobe. The

* Corresponding author.
E-mail address: flj212@126.com (L. Fan).

https://doi.org/10.1016/j.suronc.2018.10.009
Received 12 June 2018; Received in revised form 26 September 2018; Accepted 25 October 2018

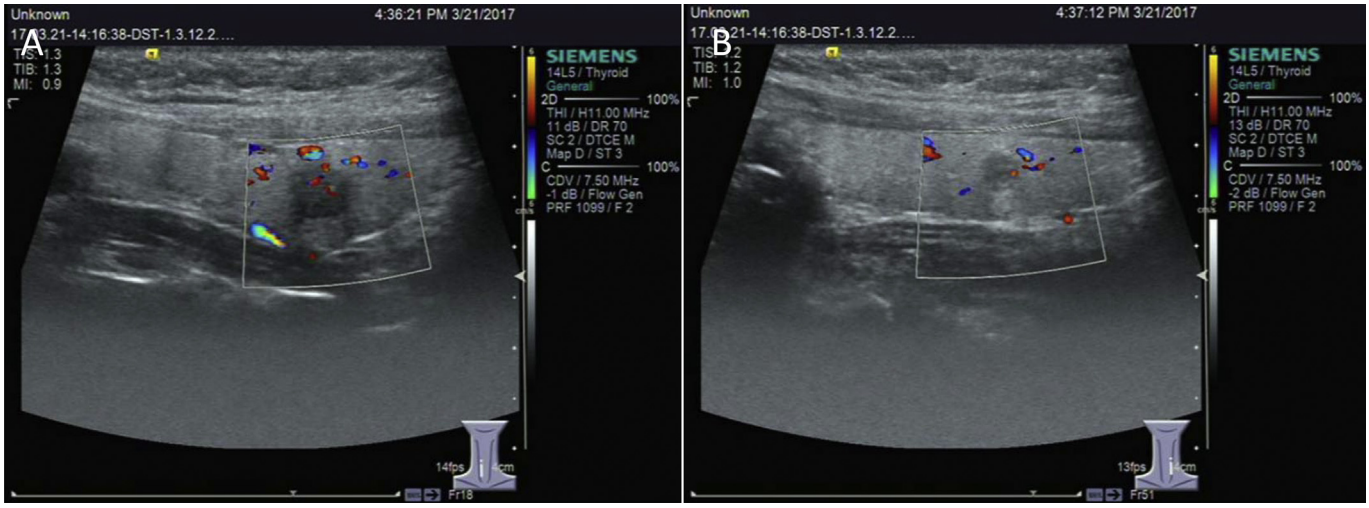

Fig. 1. Color Doppler ultrasonography after admission showing a 7 × 7 × 6 mm hypoechoic area in the middle and inferior part of the right lobe (A), with an unclear border and dot- or line-like blood flow signals inside, and 3 × 3 × 3 mm hypoechoic nodule in the middle part of the left lobe (B) classified as Thyroid Imaging Reporting and Data System category 4b.

patient was diagnosed with right papillary thyroid cancer.

After preoperative preparation and informed consent signed, robotic bilateral thyroidectomy plus right central lymph node dissection was performed under general anesthesia. During left thyroidectomy, we found that the left inferior parathyroid gland was just under the true capsule. Subsequently, the super-meticulous capsular dissection was used for *in-situ* preservation of the parathyroid gland.

2.2. Surgical procedure

Tracheal intubation was implemented for anesthesia. The patient was placed in a supine position, with the shoulder and back elevated by pads. The head was maintained in a backward and hyperextended position, and the right upper limb was abducted by 90°.

The right axilla and bilateral areola approach was adopted [4]. The incision sites were marked on the right axillary line and in the medial margin of the bilateral areolae, and the line from each incision site to the superior border of the inner clavicle and right and left sternoclavicular joints, respectively, were used to guide the trajectory of the trocars. In total, 200–400 ml of epinephrine saline (1: 200,000) was injected into the subcutaneous space along the trajectory to produce swelling. A 1–2 cm skin incision was made according to the preoperative marks, and the trocars were inserted along the pre-marked route through the subcutaneous space and into position at the superior border of the clavicle and sternoclavicular joints, respectively. The robot (da Vinci Surgical System; Intuitive Surgical, Inc., Sunnyvale, CA, USA) was docked along the midline in a cephalad direction. The trocars in the right axilla and left areola were connected to Arms 2 and 1 of the robot, respectively. The trocar in the right areola was connected to the arm equipped with a 30° dual-channel endoscope (Intuitive Surgical, Inc.), and CO_2 was insufflated to a pressure of 6 mmHg. The instrument positioning for the unilateral axilla and bilateral areola approach was shown in Fig. 2.

Fenestrated bipolar forceps (Intuitive Surgical, Inc.) were inserted into the trocar in the right axilla. A monopolar cautery device (Intuitive Surgical, Inc.) or HARMONIC ACE® curved shears (Ethicon Endo-Surgery, Cincinnati, OH, USA) were inserted into the trocar in the left areola. We dissected a flap under the platysma from the upper sternal fossa, bilateral to the midline of the sternocleidomastoid muscle and up to the upper edge of the thyroid cartilage. Then, we cut through the linea alba cervicalis, inserted a special thyroid retractor through the skin in the lower third of the right sternocleidomastoid muscle, retracted the right strap muscle to expose the right thyroid gland, and removed the right thyroid gland. The superior and inferior parathyroid glands on the right side were preserved *in situ* using the meticulous capsular dissection technique (Fig. 3). The lymphoid tissue of the right central area was removed.

In the same way, the left thyroid gland was resected, but no parathyroid gland was found when cutting the inferior blood vessels. When the posterior part of true thyroid capsule was detached from the middle third of the thyroid gland, parathyroid gland-like tissue was found deep within the true thyroid capsule, with independent blood vessels at its lower edge visible through the capsule (Fig. 4). Then, the new surgical technique, called super-meticulous capsular dissection, was performed to protect the subcapsular parathyroid as well as its blood supply. The true thyroid capsule was cut through along the upper and inner edges of the tissue to further expose it in the thyroid parenchyma. It was identified as a subcapsular parathyroid gland based on its texture and color (Fig. 5). We dissected the tissue upward along the left edge of the trachea, cut Berry's ligament, carefully protected the blood vessels at the lower edge of the parathyroid tissue, and completely removed the left thyroid gland, while preserving the parathyroid gland and its blood supply *in situ* (Fig. 6 and Supplemental Video 1).

Supplementary video related to this article can be found at https://doi.org/10.1016/j.suronc.2018.10.009.

3. Results

The operation was successful, with an intraoperative blood loss of 5 ml. There was no hoarseness or limb numbness after the operation. Five days after surgery, the drainage tube was removed and the patient was discharged. Her serum PTH concentration was 43.77 pg/ml before surgery and 37.98 pg/ml on Day 1 postoperatively (normal range: 15–65 pg/ml). Her blood calcium level was 2.21 mmol/l before the operation and 2.18 mol/l after surgery (normal range: 2.10–2.65 mmol/l).

The postoperative pathologic findings indicated a diagnosis of bilateral papillary thyroid cancer, with metastasis in five of nine for the right central lymph nodes. ^{131}I was administered 2 months after the operation. The patient was followed up for 15 months, and her serum calcium and PTH levels remained in the normal range. Her thyroglobulin level was < 0.04 ng/ml in the unstimulated state. No residual disease of the thyroid or enlarged lymph nodes of the neck were evident on color Doppler ultrasound.

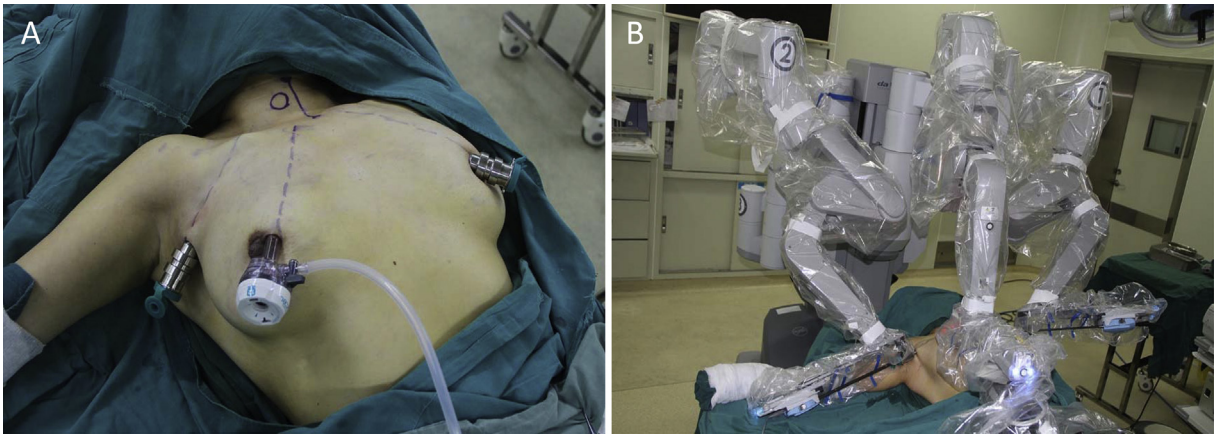

Fig. 2. The instrument positioning for the unilateral axilla and bilateral areola approach without (A) or with (B) the Arms of robot.

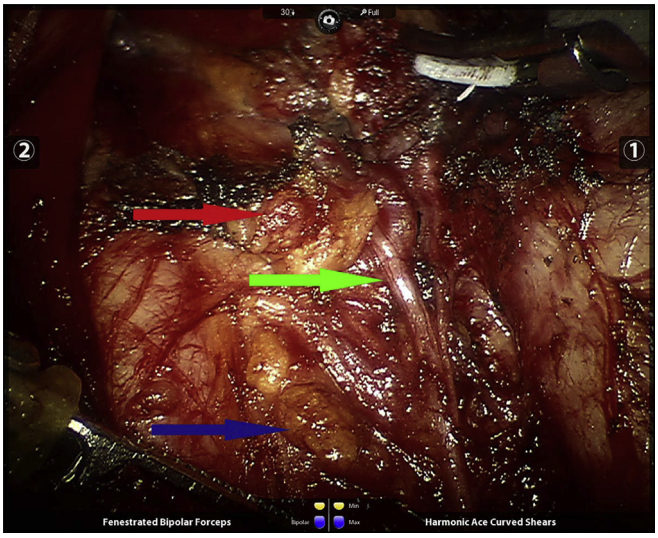

Fig. 3. Well-preserved superior and inferior parathyroid glands after right thyroidectomy and central lymph-node dissection. The red arrow indicates the right superior parathyroid gland, the blue arrow indicates the right inferior parathyroid gland, and the green arrow indicates the right recurrent laryngeal nerve.

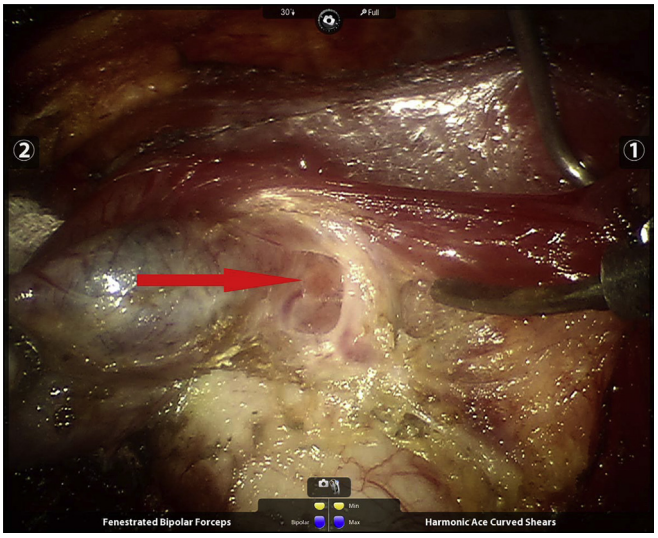

Fig. 4. Upon dissecting the posterior part of true capsule of the left thyroid, parathyroid gland-like tissue (indicated by the red arrow) was found deep within the true thyroid capsule, with independent blood vessels at its lower edge visible through the capsule.

4. Discussion

Studies have shown that the incidences of temporary and permanent hypoparathyroidism are 27.7% and 6.3% after total thyroidectomy, 36.1% and 7% after total thyroidectomy plus unilateral central lymph node dissection, and 51.9% and 16.2% after total thyroidectomy plus bilateral central lymph node dissection, respectively [1]. Temporary hypoparathyroidism causes transient hypocalcemia, which reduces patients' quality of life for a time; in contrast, permanent hypoparathyroidism results in lasting hypocalcemia, which manifests as numbness of the hands and feet and tics of the limbs and is perpetually detrimental to the quality of life of the patient. Hypoparathyroidism after thyroid surgery mainly occurs because of the small size of the parathyroid gland and extensive variation and delicacy of its blood supply, both of which can lead to mis-resection or damage during thyroid surgery.

To enable their protection, Zhu et al. [3] classified parathyroid glands into two types, A and B, based on their positional relationship with the thyroid. In Type A, the compact type, the thyroid and parathyroid glands are closely related, making it difficult to retain the parathyroid gland *in situ*. Type A is further divided into three subtypes: Type A1, in which the parathyroid gland is attached to the surface of

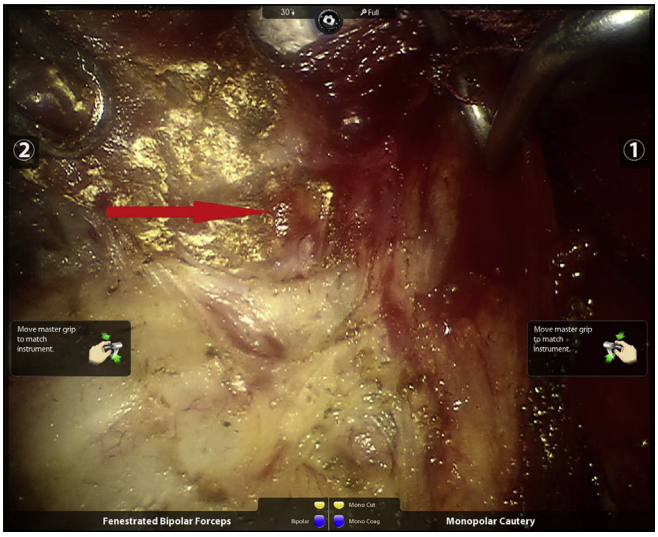

Fig. 5. We cut through the posterior part of true capsule of the thyroid, exposing and preserving *in situ* the subcapsular parathyroid gland (indicated by the red arrow) and its blood vessels.

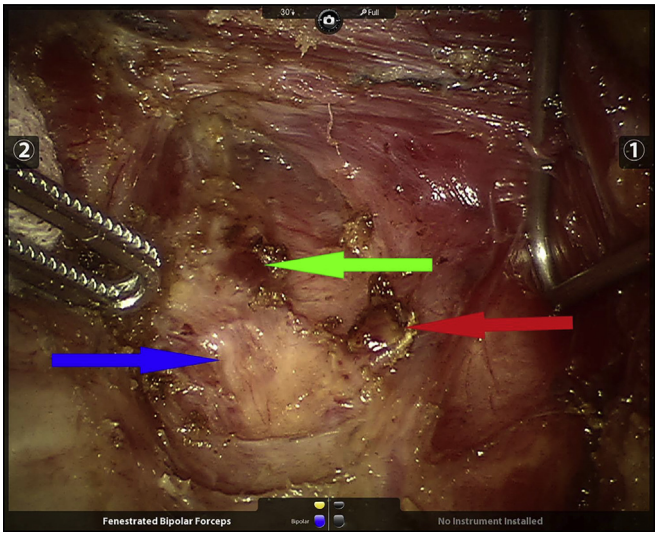

Fig. 6. After left thyroidectomy, the left superior and inferior parathyroid glands were well preserved, with a small amount of normal thyroid tissue around them to protect their blood supply. The red arrow indicates the left inferior parathyroid gland, the green arrow indicates the left superior parathyroid gland, and the blue arrow indicates the left recurrent laryngeal nerve (behind the true thyroid capsule).

the thyroid but outside the true capsule; Type A2, in which the parathyroid gland is partially or fully embedded in the thyroid but outside the true capsule; and Type A3, in which the parathyroid gland is entirely within the thyroid tissue and inside the true capsule. In Type B, the non-compact type, there is a natural gap between the parathyroid and thyroid glands, making it easier to retain the parathyroid gland *in situ*. Moreover, classification according to blood supply and location considers a parathyroid gland within the thyroid parenchyma as a separate type that it is impossible to preserve *in situ* and that can only be heterotopically transplanted after removal [5].

However, following the advances in surgical techniques, robotic surgery has been approved by the United States Food and Drug Administration for thyroid and parathyroid surgery, and has become an alternative to conventional thyroid surgery [6,7]. Robotic surgery offers three-dimensional imaging at over 10 × magnification, meaning that the surgeon can clearly identify the parathyroid glands. Moreover, the EndoWrist® instruments enable the surgeon to accurately dissect even the true thyroid capsule. In this case, 3D imaging could identify the parathyroid gland just under the thyroid capsule. In this report, the new surgical technique, namely super-meticulous thyroid capsular dissection, was successfully performed to achieve *in-situ* preservation of the subcapsular parathyroid gland during the robotic surgery. The key points of this technique are: (1) the true capsule is carefully cut through to identify the subcapsular parathyroid, (2) the anatomic structure of the subcapsular parathyroid gland is well preserved, and (3) the blood supply of the parathyroid gland is well protected by preserving the true thyroid capsule surrounding it; thus, the postoperative hypoparathyroidism was avoided. In fact, Park and colleagues [8] also found the incidence of post-thyroidectomy hypoparathyroidism decreased significantly after using the vasculature-preserving technique, which aimed to preserve the blood flow of the parathyroid gland, further supporting the advantages and usefulness of our technique. To the best of our knowledge, this is the first study to report the *in-situ* preservation of the subcapsular parathyroid gland and the technique of super-meticulous thyroid capsular dissection during robotic radical thyroidectomy.

Traditional surgical methods cannot achieve *in-situ* preservation of subcapsular parathyroid glands because of their location in the thyroid parenchyma. Traditional surgery is performed between the two (true and false) layers of the thyroid capsule: even with meticulous capsular dissection, traditional surgery can only free and excise the true thyroid capsule, meaning that the subcapsular parathyroid gland can only be identified *in vitro* after the gland has been removed [3]. Although heterotopic transplantation can be used to compensate for mis-resection of the parathyroid gland, it is time-consuming and troublesome; moreover, it is difficult to distinguish ischemic parathyroid gland from thyroid tissue after isolation. Autologous transplantation of parathyroid glands is not successful in every patient, which not only increases the incidence of hypocalcemia after thyroid surgery, but also effects no substantial changes on the incidence of permanent hypoparathyroidism [9–11]. Therefore, the technique of preservation on venous and arterial vascular trunks and branches that accompany the parathyroid gland, called meticulous capsular dissection, remains the first choice to prevent hypoparathyroidism [12]. In our manuscript, we called the technique super-meticulous thyroid capsular dissection, because robotic surgery offers three-dimensional imaging at over 10 × magnification and the EndoWrist® instruments, which could not only enable the surgeon to accurately cut through and dissect the true thyroid capsule, but also identify the parathyroid gland just under the true thyroid capsule, and finally protected the blood supply of the parathyroid gland by preserving the true thyroid capsule surrounding it.

Of all types of parathyroid gland, the identification and *in-situ* preservation of those located within the thyroid parenchyma or just under the thyroid capsule is the most challenging. Because of their sophisticated blood supply and unfavorable location, total thyroidectomy cannot completely prevent hypoparathyroidism. However, wherever possible, the surgeon should identify and preserve parathyroid glands during surgery to decrease the occurrence of permanent hypothyroidism [3]. Studies have shown that 2.1–6.6% of all parathyroid glands are situated within the thyroid parenchyma [3,6,13,14]. It is necessary to raise surgeons' awareness of this so that they can identify and preserve as many of these parathyroid glands as possible. If no inferior parathyroid glands are found when handling the inferior pole of the thyroid, it should be dissected along the posterior part of true capsule, paying attention to the deep inner surface of the thyroid capsule. The capsule should be cut through if abnormal yellowish-brown or fat-like tissue under the true capsule is observed; whether it is the parathyroid gland or not should be determined, and positively identified parathyroid glands should be preserved *in situ* without changing their structure and blood supply. Simultaneously, peripheral blood vessels should be protected as far as possible. In fact, most of the parathyroid glands are close to the true thyroid capsules; thus, small blood vessels supplying the parathyroid gland can be damaged when the true thyroid capsule is excised. Therefore, in addition to the parathyroid gland, the true thyroid capsule closing it should also be preserved *in situ* as far as possible. In this way, using the technique of super-meticulous thyroid capsular dissection, the blood supply to the parathyroid gland could also be preserved more efficiently, which is crucial for the survival and function of the parathyroid. As previously reported [8], we also failed to get the evidence of preservation of specific subcapsular parathyroid gland by supra-selective measurement of PTH level from the thyroid vein or pathohistology of parathyroid gland tissue fragment owing to the complexity and difficulty of these methods. However, the current patient's serum parathyroid hormone concentration was 43.77 pg/ml before and 37.98 pg/ml after surgery (normal: 15–65 pg/ml), which indicated that all the functions of parathyroids was protected. In addition, for an experienced surgeon, the parathyroid gland could be successfully identified and its blood supply could be well preserved based on texture and color.

In conclusion, the super-meticulous capsular dissection, which could cut through the true capsule to identify subcapsular parathyroid and protect its anatomic structure as well as blood supply, is recommend for *in-situ* preservation of subcapsular parathyroid gland during robotic radical thyroidectomy.

Competing financial interests

The authors declare no competing financial interests.

Funding

This study was supported by grants from Science and Technology Innovation Project for Social Livelihood of Chongqing from Chongqing Science and Technology Commission (No. cstc2015shmszx120072) and Talents Training Program of Third Military Medical University (No. 2017MPRC-18).

Acknowledgments

We would like to extend our sincere gratitude and appreciation to Ying Zhang from University of San Francisco, San Francisco, CA, USA, and Junlan Liu from Breast and Thyroid Surgery, Southwest Hospital, Third Military Medical University, Chongqing, China for proofreading.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.suronc.2018.10.009.

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