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Robotic transaxillary parathyroidectomy: surgical technique and pearls ☆

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With the advances in preoperative localization studies and greater demand for minimally invasive procedures, novel targeted approaches to the parathyroid glands have been described and practiced over the past 2 decades. Despite these various surgical options, no single technique has been established as superior to another. Recently, robotic surgery has evolved from a novel technique with an anticipated potential to overcome the limitations associated with endoscopic techniques, to the preferred surgical procedure in multiple surgical disciplines. Their application in head and neck surgery has gained wide popularity in Asia and recently in European and North American practice. This article reviews the application of robotic technology to further assist surgeons in accomplishing parathyroidectomy.
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Historically until the 1990s, a collar incision involving bilateral cervical exploration of all 4 parathyroid glands and removal of any that are grossly enlarged has been the standard surgical treatment for primary hyperparathyroidism (PHPT). In the past 2 decades, significant improvements in the accuracy and reliability of preoperative localization studies have facilitated further evolution in surgical management, allowing a more targeted minimally invasive surgical approach.[1] Because 80%-90% of patients with PHPT have a solitary parathyroid adenoma, resection of 1 gland leads to cure in most cases. The first unilateral approach for solitary parathyroid adenomas was reported by Tibblin et al.[2] Since then, several targeted techniques have been described, including radio-guided parathyroidectomy, endoscopic parathyroidectomy with gas insufflation, and video-assisted parathyroidectomy without gas insufflations.[3-5]

The confluence of improved preoperative adenoma localization and the concomitant advent of minimally invasive technology have led to fewer complications, shorter operative time and hospitalization, quicker recovery, and greater patient satisfaction.[6] Therefore, targeted parathyroidectomy has replaced bilateral neck exploration in patients with localized disease, although a traditional cervical incision with bilateral neck exploration remains the optimal surgery for nonlocalized disease and cases of hyperplasia, that is, multiple endocrine neoplasia type 1 or 2a, familial hyperparathyroidism, and secondary hyperparathyroidism.[4,7]

As technology and training advanced, the da Vinci Surgical Robot System (Intuitive Surgical, Sunnyvale, CA) has recently evolved as an adjunct to endoscopic head and neck surgery. Surgeons have found that the ability to control a high definition camera system and multiarticulated endoscopic arms through a single console restores some of the fundamentals of the surgical technique that were lost in conventional endoscopic surgery, making it particularly advantageous in the restricted workspace afforded in this region of the body.[8-12] Robotic parathyroidectomy has been

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described recently in a few case reports and small series.[1,7,13,14] The robotic transaxillary approach permits a safe, precise, magnified dissection without the need for CO_2 insufflation and has a better cosmetic result due to the invisible scar in the neutral position.

This article aims to provide the reader with an overview of the approach and patient preparation required for robotic parathyroid surgery. Today's patients seek out surgeons who can and will offer the least invasive option when appropriate. Head and neck surgeons should therefore be facile in each of the targeted techniques so that each approach can be individualized on the basis of any given situation.

Indications

It was only during the last 2 decades that minimally invasive parathyroidectomy was widely established. The development of high-resolution ultrasound (US), sestamibi scintigraphy, and introduction of the rapid intraoperative parathyroid hormone (PTH) assay has greatly laid the foundation for minimally invasive and targeted parathyroidectomy.[15,16] If preoperative localization studies allow for a more targeted approach, the intraoperative PTH assay is able to intraoperatively confirm the success for surgery before the patient leaves the operating table.[17]

The diagnosis of PHPT is established by demonstrating hypercalcemia in the setting of an elevated intact PTH level. Familial hypocalciuric hypercalcemia and vitamin D deficiency must be ruled out by measuring the 24-hour urine calcium and serum vitamin D levels, as surgery will not be required in these patients. PHPT is most commonly due to a single adenoma. However, approximately 15% of cases may be a result of multiple gland disease, either due to 4-gland hyperplasia or double adenomas. Although most commonly a sporadic disease, PHPT due to multiple gland disease can be part of a familial syndrome in a small subset of patients (5%). Indications for parathyroidectomy are no different in patients with sporadic or familial PHPT.[18,19] However, patients with sporadic PHPT with an adenoma localized by preoperative imaging techniques are candidates for targeted parathyroidectomy, such as robotic parathyroidectomy. This procedure takes advantage not only of the targeted approach but also of the endoscopic magnification that allows performing the same intervention through a remote "scarless" access. This is theoretically associated with a lower risk of complications owing to optimal 3D visualization of neck structures, in particular the recurrent laryngeal nerve (RLN) and parathyroid glands. Nonetheless, ideal patient selection criteria should be established (Table 1). Patients should also be screened for contraindications to the robotic surgical approach, such as rotator cuff pathology; shoulder or neck mobility problems; cervical spine disease; previous neck, chest, or axillary surgery; and possible complicating conditions, such as breast implants and previous irradiation, obesity, and certain thyroid pathologies.

Table 1 Contraindication to targeted parathyroidectomy

(1) Previous neck surgery or irradiation of the neck.
(2) Equivocal preoperative localization studies.
(3) Suspected multiglandular disease.
(4) Parathyroid carcinoma.
(5) Voluminous goiter.

Preoperative considerations and surgical planning

Imaging before surgery can help guide the surgical approach by localizing the adenoma in many patients. Of all the imaging modalities, US is the least expensive and least invasive, it does not involve radiation and is readily accessible. Parathyroid glands appear as well-circumscribed and oval, hypoechoic, and usually solid nodules. The sensitivity of US detection of parathyroid adenomas ranges from 27%-95%, with a specificity of 92%-97%. It is the operator's experience that has the greatest effect and likely accounts for the wide range of reported sensitivity. The combination of US and sestamibi scan may increase the accuracy of localization of a single adenoma to 94%-99%, as each modality contributes different data to help determine the gland location. Ultrasonography is more specific for anatomical location of the gland in relation to the thyroid, whereas scintigraphy is better at finding ectopic glands especially in the mediastinum.[20] The availability of US has led some surgeons to further use it in the operating room. It can be used for identifying the parathyroid adenoma and its anatomical location just before surgery. US may also assist in precisely localizing the incision once the patient is in the neck extension position. Lastly, US-guided fine-needle aspiration can be considered to confirm intrathyroidal parathyroid adenomas or in selected cases of persistent or recurrent HPT after failed exploration. An elevated PTH washout concentration from the fine-needle aspiration can help identify parathyroid gland lesions. With the PTH washout technique, minimally invasive surgery can be implemented even with negative cytology, thus allowing success of a targeted surgical approach in difficult redo cases.

Four-dimensional computed tomography (4D-CT) scan generates exquisitely detailed, multilane images of the neck and allows the visualization of differences in the perfusion characteristics of hyperfunctioning parathyroid glands (ie, rapid uptake and washout), compared with normal parathyroid glands and other structures in the neck. The images that are generated by 4D-CT provide both anatomical information and functional information in a single study that the operating surgeon can interpret easily and may serve an important role in localization before both initial and reoperative parathyroid procedures.[21]

To further improve the surgical success of targeted parathyroidectomy and to minimize the possibility of persistent or recurrent HPT after surgery, some have advocated the use of surgical adjuncts, such as intraoperative PTH monitoring. Intraoperative PTH is useful in assessing the adequacy of resection by functional means without the need to expose all the parathyroid glands. The