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Minimally Invasive and Remote-Access Thyroid Surgery in the Era of the 2015 American Thyroid Association Guidelines

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Thyroid surgery has evolved throughout the years from being one of the most dangerous surgeries to becoming one of the safest surgical procedures performed today. Recent technologic innovations have allowed surgeons to remove the thyroid gland from a remote site while avoiding visible neck scars. There are many endoscopic approaches for thyroidectomy. The most common cervical approach is the minimally invasive video-assisted technique developed by Miccoli et al. The robotic transaxillary and axillary breast approaches avoid a neck scar and have been demonstrated to be safe and effective in international populations. Novel approaches under investigation include face-lift robotic thyroidectomy and the transoral approach. This article aims to provide the reader with an overview of the current minimally invasive and alternate-site approaches used and their capability to assist the surgeons in accomplishing remote-access thyroid surgery under the scope of the 2015 American Thyroid Association Guidelines.

INTRODUCTION

Traditional thyroid and parathyroid surgery is performed through a cervical incision to expose the thyroid. Despite the safe dissection and low morbidity in experienced hands, some patients are left with a relatively prominent scar. A large percentage of these patients include young women who are concerned about visible scars. As a result, both surgeons and patients aim to minimize surgical incisions or relocate them outside the neck.

Endoscopic techniques first evolved in the field of parathyroid surgery.[1] Advances in endoscopic instrumentation, preoperative localization studies, and increased understanding of endoscopic cervical anatomy facilitated the growth of head-and-neck endoscopic surgery for the management of thyroid and parathyroid disease.[2–9] Since its introduction in the 1990s, robotic surgery has evolved from a novelty to become the favored approach in some cases within several surgical disciplines such as urology,[10] gynecology,[11] and cardiothoracic surgery.[12–16] The evolution of robotic head and neck surgery has expanded on the earlier achievements of endoscopic surgery for thyroid and parathyroid disease. The Korean experience especially has documented excellent aesthetic outcomes with minimal morbidity.[17–21] Surgeons have found that the ability to control a magnifying, three-dimensional (3D), high-definition camera system with a stable platform and multi-articulated tremor-free endoscopic arms through a single console restores some of the fundamentals that were lost in the transition to endoscopic surgery. This is advantageous in the restricted workspace in this region of the body.[8,20,22]

In 2015, the American Thyroid Association (ATA) published new guidelines surrounding the management of thyroid nodules[23] that clarified the role of preoperative imaging and testing (e.g., molecular marker testing) and addressed the extent of thyroid surgery. Total thyroidectomy was previously indicated in well differentiated thyroid carcinoma but was changed to reflect the indolence of most of these tumors, the conclusion being that thyroid lobectomy may be sufficient for tumors smaller than 4 centimeters.

Previously, some authors felt that, given the limited exposure of the contralateral lobe, common remote approaches were not well suited for a total thyroidectomy. Additionally, approaches such as the face-lift approach would have required bilateral incisions with extensive dissection.[24] Given that the new guidelines may decrease the role of total thyroidectomy in the future,[23] it is possible that minimally invasive approaches may become more popular. The traditional cervical incision provides excellent access and safety, and any new techniques must at least meet these marks. Many options are being developed to improve cosmesis but have not yet been widely adopted for a number of reasons, some of which were reviewed in a recent statement from the ATA.[25] The history of efforts toward improved cosmesis and the current state of the art are reviewed here in relation to the 2015 ATA guidelines.[23]

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MATERIALS AND METHODS

Minimally Invasive Video-Assisted Thyroidectomy

Video-assisted thyroidectomy through a minimal access cervical incision was initially championed by Miccoli et al.[26] Their early descriptions of a small incision used primarily for hemithyroidectomy or benign tumors is informative, especially subsequent reports from the same group adopting total thyroidectomy for malignant tumors and central neck dissection.[27] The operative time, volume, and conversion rates of this group have stood the test of time but do require a cervical incision, which can still be problematic to some.

Endoscopic Thyroidectomy

In 2000, Ohgami et al. reported the first remote-access thyroidectomy, which was completed with multiple ports using endoscopes.[28] Subsequent efforts have continued, primarily in South Korea, where body habitus and reimbursement patterns encourage increased volumes.[25] Several remote-access approaches have been attempted to place the incision in a more favorable location, including breast, axillary, face-lift, and transoral approaches. The prolonged learning curve necessary for remote access without wristed instrumentation has led some groups to adopt robotic instrumentation.

Transoral Neck Surgery–Endoscopic

Given the proximity, the superior-to-inferior and bird's eye view, and a scarless outcome, the oral cavity also has been utilized to remove the thyroid gland. Wilhelm et al. were the first to report natural orifice transluminal endoscopic surgery (NOTES) thyroidectomy, but they had a 25% rate of recurrent laryngeal nerve (RLN) palsy and a conversion to an open approach in three of eight patients.[29] To avoid airway complications, Nakajo et al. in 2013[30] and Wang et al. in 2014[31] adopted an oral vestibular approach but experienced mental nerve injury and paresthesias. Modifications by Anuwong in 2015 generated similar operative times and outcomes to conventional surgery and have garnered increasing attention.[32] Given the ability to avoid any external incision, NOTES approaches potentially offer the most appealing option but were not reviewed in the recent ATA statement.[25] To differentiate between the other NOTES approaches described, the term *transoral neck surgery* (TONS) has been proposed, which can be designated as robotic (TONS-R) or endoscopic (TONS-E).

Robotic Thyroidectomy

The wristed instrumentation, additional arms, and improved visualization with the da Vinci robot (Intuitive Surgical Inc., Sunnyvale, CA) encouraged some groups to merge this technology with existing remote-access approaches. Literature since Lobe et al.[33] reported the first robotic thyroidectomy via a transaxillary approach in 2005 suggests that the advantages of robotic thyroidectomy may justify the expense in some situations. Lee et al.[34] reported improvement over the endoscopic approach, including lymph node yield and operative time.

Remote-access sites include breast, bilateral axillo-breast, axillary, face-lift, and oral vestibular approaches, some of which were reviewed in the 2016 ATA statement.[25] Kandil et al. [35] reported their first 100 cases using a transaxillary approach, the largest remote-access experience in the United States. They reported improvement between early and late cases, and increased difficulty with obese patients. Terris et al.[18] reported the largest series to date in the United States utilizing a robotic face-lift approach, with 18 procedures and operative times of about 2.5 hours. Unpublished results from our group demonstrate similar numbers without long-term complications.

Transoral Neck Surgery–Robotic

Endoscopic efforts have served as a vanguard for the adoption of robotic advantages. Our group and others have pioneered utilization of the da Vinci robot (Intuitive Surgical Inc.) via either a floor-of-mouth or vestibular approach.[16,36] While the floor of mouth was first attempted, the premental vestibular approach avoids the risk of airway compromise from floor-of-mouth swelling and has gained favor in our hands. Transoral techniques have resulted in excellent cosmesis without permanent mental or recurrent laryngeal nerve injuries (unpublished data), and have capitalized on the benefits of more recent iterations of the da Vinci robot (Intuitive Surgical Inc.) (unpublished data).

Indications and Patient Selection

Ideal patient selection criteria have been proposed for several different approaches.[37] In general, the best candidates are nonobese (body mass index < 30) young patients, without extensive comorbidities or advanced disease, with a history of keloid or hypertrophic scar—or otherwise motivated to avoid a cervical incision. The remote-access approaches are usually deferred in patients with a previous history of neck surgery or irradiation of the neck. Relative and approach-specific contraindications include rotator cuff pathology; shoulder/neck mobility problems; cervical spine disease; and previous neck, chest or axillary surgery.

Surgical Techniques

Robotic Transaxillary Thyroidectomy. The majority of the experiences of U.S. and Asian surgeons of robotic transaxillary thyroid surgery are limited to cases series and small prospective and retrospective studies reporting surgical outcomes in the initial learning curve.[17,35,38] Modifications to this approach were necessary to accommodate the dynamics of a Western population to ensure the safe replication by U.S. surgeons.[35] Eventually, doubts were raised on the procedure's safety through a unilateral axillary incision in certain cases.[39] Comparable to the Korean experience,[17] Kandil et al. showed a learning curve of 45 cases.[35] The complications, coupled with the technicality and higher costs, tempered the enthusiasm of some surgeons in the West.[24,40]

This technique includes flap creation under direct visualization to create a working space, docking the robot system, and console operative. Patients are placed in a supine position under general anesthesia and intubated with an nerve integrity monitor (NIM) endotracheal tube (Medtronic Xomed Inc., Jacksonville, FL) to allow monitoring of RLN function. The neck and arm position is as described by Ikeda et al.[41] An axillary incision is made along the lateral border of the pectoralis major muscle. A subcutaneous flap is raised in a subplatysmal plane until the clavicle, and a window is developed between the sternal and clavicular heads of the sternocleidomastoid muscle (SCM). A specially designed retractor is placed under the sternal head of the SCM and strap muscles, creating the working space superficial to the thyroid. The da Vinci Si robot (Intuitive Surgical Inc.) is docked from the side of the bed contralateral to the operative field with the endoscope, Harmonic scalpel, and Maryland forceps entering via the axillary incision. A chest wall incision can be used in early experience to assist in dissection of the thyroid gland.

Robotic Face-Lift (Postauricular–Occipital) Approach. Terris et al.[18] described the feasibility of this technique in 14 patients using the posterior limb of a parotidectomy–face-lift incision, which results in decreased dissected area compared to the other remote-access techniques. Adoption in the United States has been slow, however, as demonstrated by limited subsequent reports.

The incision is made adjacent to the postauricular crease, crossing to the occipital hairline to be obscured by the ear. The patient is placed supine with the head turned 30 degrees away from the side of lobectomy. The open dissection proceeds through a sequential identification of structures starting with the SCM. The dissection plane can be either superficial or deep to platysma. The dissection plane remains superficial to the great auricular nerve after identification. The omohyoid is reflected ventrally to access the superior pole of the thyroid gland. A customized retractor is placed underneath the strap muscles to maintain the operative pocket, and a Greenberg retractor is used to retract the SCM. The da Vinci robotic system (Intuitive Surgical Inc.) is deployed. Three arms are usually used due to the limited space. Dissection continues along the superior pole in a step-wise fashion.

Chest/Breast Approaches. Although multiple chest and breast approaches have been utilized internationally with great success, none have garnered a significant following in the United States to date.

In 2000, Ohgami et al.[28] employed the Anterior breast approach, which involved a 15-mm transverse incision between the parasternal borders at the level of the nipples using a 12-mm trocar and 10-mm flexible endoscope. Modifications involved bilateral superior areolar incisions. In the axillo-bilateral breast approach (ABBA), the endoscope is typically inserted via one of the areolar 5-mm incisions, and the dissection is accomplished via instruments introduced through the 20-mm axillary incision(s).[42,43] This approach was first described by Schimazu et al. in 2003.[42] Choe et al.[44] modified the ABBA by making bilateral axillary incisions. The bilateral axillo-breast approach (BABA) involved having two 12-mm ports inserted via each circumareolar incision and two 5-mm port inserted via each axillary incision. Also in 2003, Park et al.[45] described slightly different incisions locations. An incision was made bilaterally on each upper circumareolar area, one 12-mm trocar for the endoscopic instruments and the 15-mm trocar for the flexible endoscope. A 5-mm trocar was inserted in the third 3-cm incision below the clavicle of the lesion side.

Transoral Neck Surgery. Benhidjeb et al. reported a series in which transoral video-assisted thyroidectomy was possible.[46] Instead preferring a vestibular approach, Anuwong later reported excellent results similar to open techniques.[32] Continued development of these techniques has led to success in nearly 800 cases internationally (personal correspondence). Here we describe the approach, which has become our preferred one.

The patient may be intubated either via a nasotracheal or traditional endotracheal positioning. A 10-mm incision is made in the gingivobuccal sulcus above the frenulum. This is infiltrated with a saline and epinephrine solution and then bluntly dissected over the midline mandible into the submental subplatysmal plane. Two 5-mm incisions are made lateral to each canine in the sulcus near the level of the lip, which are also infiltrated. Ports are placed in all three incisions, with the camera in the central port. A subplatysmal plane is opened to the level of the sternal notch, and the median raphe is identified. The isthmus is next divided, and soft tissue is bluntly dissected around the lobe of interest. A retraction stitch may be placed on the sternothyroid to facilitate visualization of the superior pole, which is developed bluntly via hand-over-hand dissection. The superior pole vessels are secured with endoclips or alternative thermal ligation methods. The recurrent laryngeal nerve is identified near its insertion, and the remainder of the thyroid lobe is removed. The parathyroid glands are readily visualized with this approach. Furthermore, central neck dissection is facilitated by visualization of the RLN and the central neck itself. A drain may be placed via a separate stab incision in the lateral neck, whereas others use a transaxillary approach for drain placement when indicated. This drain site may serve as a window for an additional arm if needed intraoperatively, as recommended by some teams. The disadvantage of drain placement is the necessity of a visible incision, albeit small.

The above listed approach has been described via both endoscopic (TONS-E) and robotic (TONS-R) techniques. The majority of cases have been completed endoscopically, but our group has had success with both approaches. The benefits of 3D and magnified visualization can be counterbalanced by the additional expense and loss of haptic feedback with the robot. Further efforts are needed before one method can be declared superior.

The TONS approaches lack a visible scar and offer a favorable relationship of the RLN when visualized from a superior to inferior angle: the nerve, especially on the right, descends away from the insertion point. This allows rapid completion of the case, with very minimal dissection of the RLN, once it has been identified. Although this distal-to-proximal approach is an uncommon pattern for most thyroid surgeons, there may be some advantages with less traction at the ligament. We believe this procedure will continue to gain favor; it has become our preferred noncervical approach as of this writing. Of all approaches, this offers the best cosmetic result and most closely approximates the Kocher incision in operative time and safety profile.

Complications

Any new technique should be compared to the gold-standard cervical approach. Complications not associated previously with thyroid surgery have occurred with published and unpublished reports of brachial plexopathy, esophageal perforation and transection, and high-volume blood loss.[17,24,35,47] The over-traction of arm positioning and brachial plexus neuropraxia can lead to prolonged paresthesia of the skin flaps and muscle stiffness. Some complications can be avoided by using somatosensory evoked potentials (SSEP) monitoring in the transaxillary approach[48] or using alternative remote-access approaches.

RESULTS

After reviewing the available literature, the 2016 ATA statement on remote-access thyroid surgery concluded that there is a role for remote-access thyroid surgery in highly motivated patients.[25] The North American population poses technical and financial disincentives to the development of remote-access approaches, however. Some authors have suggested that the increased cost of remote-access techniques impairs the financial viability of such approaches.[24,40] In addition, the 2011 withdrawal of U.S. Food and Drug Administration support of robotic thyroidectomy may have played a role.

There is a consensus that there is a learning curve with remote-access surgery.[17,35,38] Laparoscopic and robotic skills must be mastered, and the unfamiliar angles of dissection must be anticipated. These pitfalls are addressed to some degree by careful patient selection. In order to become a common procedure, the learning curve must be broached, and for a multitude of reasons this consistently has not occurred in the United States. The excellent safety and efficiency of the Kocher incision set a high bar that has dissuaded many surgeons.

Despite the limitations in any new surgical approach, the demand for improved cosmesis will drive innovation. Ryu et al. in Korea demonstrated improvement in patient satisfaction with final cosmesis following robotic thyroidectomy when compared to conventional approach.[49] Quality-of-life studies continue to demonstrate that the cervical incision can be burdensome.[50]

Furthermore, 2015 ATA guidelines may increase the role of remote-access surgeries by suggesting that in the appropriate scenario thyroid lobectomy may be sufficient.[23] This may increase patient interest because indeterminate lesions that ultimately are found to harbor a well differentiated thyroid carcinoma may not require further intervention. What previously would have been considered a diagnostic lobectomy may now be considered therapeutic in the appropriate situation.

Alternatively, the revised ATA guidelines suggest observing smaller nodules without biopsy due to the indolent course of most thyroid cancer.[23] This may result in fewer interventions on the small nodules, which historically have been the mainstay of remote-access interventions. Calls for decreasing healthcare resource utilization worldwide may also repress innovation when third-party payers and government entities are charged with containing costs. Payment models that transition cost to motivated patients will be required before the additional time and resources can be routinely justified. Currently, high-volume thyroid surgeons would seem to be best situated to perfect these techniques.

Series of less-invasive interventions offer clues toward future approaches to managing thyroid nodules. In a recent presentation by Noureldine et al., our group presented results on high-intensity–focused ultrasound ablation of the thyroid in a porcine model.[51] This adds to research from Italian and Korean groups that has utilized radiofrequency ablation (RFA) in carefully selected groups.[52] Additional European groups had excellent results with modified RFA in symptomatic patients.[53,54] With growing trends toward observing thyroid nodules while lowering costs, ablative procedures without the risk of general anesthesia may become more attractive, and also may offer another cosmetic option for selected patients.

CONCLUSION

Despite the excellent outcomes provided by the traditional cervical incision, remote-access approaches offer motivated patients improved cosmesis. The 2015 ATA guidelines[23] that encourage lobectomy for some thyroid carcinomas may spur the growth of these more cosmetically favorable procedures. Although widespread U.S. adoption has been slow due to technical, population, and financial considerations, new modifications have led to promising results at some high-volume centers where the learning curve can be passed. The ideal thyroid surgery will provide improved cosmesis with time and safety profiles similar to the Kocher incision. Future research will continue to lead to improved outcomes, which ultimately may drive further demand.

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