Minimally Invasive Thyroid and Parathyroid Surgery: Where Are We Now and Where Are We Going?

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ORIGINS OF MINIMALLY INVASIVE AND ENDOSCOPIC THYROID AND PARATHYROID SURGERY

Minimally invasive endocrine neck surgery has evolved considerably over the past decade, after a somewhat humble origin. Michel Gagner performed the first endoscopic parathyroidectomy in 1996 at the Cleveland Clinic.1 Surgery lasted more than 5 hours and the patient developed massive subcutaneous emphysema. Concerns were subsequently raised regarding sustained intravascular absorption and subcutaneous emphysema from long duration of exposure to CO2 insufflation.2 In 1998, Miccoli and his team in Pisa pioneered an endoscopic technique that used a 15- to 20-mm central neck incision and only 3 to 4 minutes of CO2 insufflation to create an operative pocket.3 Once the working space was created, visualization was maintained using external retractors. The procedure continued to develop and eventually involved no use of CO2 insufflation. The operative pocket was created by minimal dissection through the anterior neck incision and visualization of the operative field was obtained using a 5-mm 30-degree high-resolution endoscope. Randomized controlled studies comparing endoscopic parathyroidectomy with conventional bilateral neck exploration confirmed decreased operative times, improved cosmesis, and reduced postoperative pain in the endoscopic group with 100% cure rates in both groups.4

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Endoscopic and minimally invasive thyroid surgery evolved from these original investigations in parathyroid surgery. Paolo Miccoli in Pisa and Rocco Bellantone in Rome essentially simultaneously developed similar minimally invasive video-assisted approaches to performing thyroid surgery. The fundamentals developed by these surgeons have carried forth through this decade, and consist of a small single central incision, use of advanced energy devices to maintain hemostasis in a small space, and endoscopic guidance primarily for the management of the vasculature of the thyroid gland and the identification and preservation of the recurrent laryngeal nerves and parathyroid glands. These procedures are accomplished without the need for drainage, and are routinely performed on an outpatient basis in the United States.

EVOLUTION OF MINIMALLY INVASIVE AND ENDOSCOPIC THYROID AND PARATHYROID SURGERY

The most widely practiced variation of minimally invasive thyroid surgery is the Miccoli technique, likely because of the relative ease of performance, combined with substantial advantages to the patient. Several investigators across Europe, in parts of Asia, and now in the United States have demonstrated that this technique can be readily performed by high-volume thyroid surgeons. As a further endorsement of this technique, several publications have appeared that clarify the oncologic safety of the procedure, demonstrate the profound cosmetic and even functional superiority relative to conventional surgery, and confirm the compatibility with other technologies such as nerve monitoring or the use of ultrasonic energy (Fig. 1).

Miccoli accomplished a compelling prospective randomized trial comparing minimally invasive video-assisted thyroidectomy with conventional thyroidectomy for the management of thyroid cancer, which served to alleviate concerns regarding the thoroughness of resection in thyroid malignancy. Postoperative measures of serum thyroglobulin level and radioactive iodine uptake confirmed that the endoscopic technique yielded a thorough thyroid removal compared with conventional thyroidectomy. In addition, prospective trials were conducted by the Miccoli and Bellantone groups in which the cosmetic and functional advantages of the endoscopic technique were validated. In a comparison between minimally invasive video-assisted thyroidectomy and conventional surgery, patients described greater satisfaction with their scar outcome and reduced pain with the minimally invasive technique. After describing

Fig. 1. The combination of advanced energy devices and high-resolution technology have prompted the possibility of using very small incisions to safely deliver diseased thyroid glands (A, B). The cosmetic outcomes are superior (C) and valued by the population of patients who often develop thyroid problems (young women).
a large North American multi-institutional application of this technique, Terris and colleagues subsequently highlighted the complementary application of endoscopic surgery and laryngeal nerve monitoring, which helps to compensate for the inherently reduced surgical aperture associated with minimally invasive surgery. A low rate of even transient nerve dysfunction was achieved. The magnified visualization of the recurrent laryngeal nerves likely contributes to the excellent functional outcomes.

The emergence of robust nuclear imaging ($^{99m}$Tc-sestamibi) and high-resolution ultrasonography have facilitated a focused approach in parathyroidectomy. Possibly the most important adjunct in the evolution of minimally invasive parathyroidectomy was the advent of a highly sensitive, rapid, parathyroid hormone assay. In 1988, Nussbaum reported the first successful use of intraoperative parathyroid hormone (IOPTH) in 12 patients undergoing parathyroidectomy. This assay has become widely available since its introduction and allows a focused surgery to be performed, with confidence that all hyperfunctioning parathyroid tissue has been removed before exiting the operating room. Although no universal algorithm has been uniformly endorsed for optimal timing of IOPTH acquisition, the generally accepted criteria is at least 50% reduction in the 10-minute postexcision level compared with the baseline level. We advocate obtaining 5-, 10-, and 15-minute postexcision levels with pre-incision level as baseline, supported by our finding that a 5-minute postexcision level may facilitate earlier termination of focused parathyroidectomy in more than 60% of cases. Traditionally, endoscopic and minimally invasive parathyroidectomy techniques have been used predominantly in the case of a single adenoma. However, as experience with the techniques increases, the indications will likely broaden. For example, recent reports suggest endoscopic bilateral neck exploration is feasible with patients with hyperparathyroidism.

THE FUTURE OF MINIMALLY INVASIVE THYROID AND PARATHYROID SURGERY

With improvements in technology, there seems to be little doubt that endoscopic surgery will continue to evolve. There are 3 likely directions of this evolution: expanded indications for the minimally invasive video-assisted thyroidectomy and parathyroidectomy, the further development of remote access surgery via several different routes, and the application of robotics to further assist the surgeon in accomplishing these

![Fig. 2. Identification of adenomatous parathyroid glands (A) is facilitated by endoscopic guidance. Visualization of other critical structures in the central compartment is also enhanced, for example the recurrent laryngeal nerves (B).](image-url)
techniques (see the article by F. Christopher Holsinger elsewhere in this issue for further exploration of this topic).

There are already early reports of the expansion of indications for endoscopic surgery. Miccoli and colleagues\textsuperscript{23,24} have described the use of this procedure for carriers of the ret proto-oncogene and for bilateral neck exploration. Bellantone and colleagues\textsuperscript{25} have published on endoscopic lymph node dissection in the central compartment and in the lateral compartment.\textsuperscript{26} In the United States, Lai and colleagues\textsuperscript{27} have described at least a small number of cases in which thyroid nodules greater than 3 cm are removed through a minimal access approach. As instrumentation improves, and as retrieval of the gland is facilitated, ever larger glands and lesions may be removed through ever smaller incisions.

There have been numerous reports of remote access thyroidectomy using surgical ports placed in several locations including the anterior chest wall,\textsuperscript{28} subclavicular region,\textsuperscript{29} or axillary region.\textsuperscript{30} The axillary region has proved to be one of the most feasible approaches, although it requires patience and a particularly sophisticated skill set.

To facilitate ease of remote access thyroid surgery and avoid the need for insufflation, the application of robotics in thyroid surgery has emerged. Originally released for human application nearly a decade ago, it is only in the last 2 years that the daVinci surgical robotic system has been used for endocrine applications. An initial report by Wright and Lobe\textsuperscript{31} reflected the feasibility of combining an axillary approach with robotic technology to facilitate removal of the thyroid gland. Although this was accomplished in a small number of patients, the Chang group\textsuperscript{32} in Korea has been able to apply this approach in a large series of patients, and recently reported on more than 100 robotic thyroidectomies. The Asian culture is such that avoidance of a cervical neck scar may justify the expense of technological investment combined with a lengthy procedure to approach the thyroid compartment remotely. As a result, this technique may not find as much applicability in other parts of the world. Nevertheless, we have pursued cautious implementation of this technique in our practice in Augusta (Fig. 3). We offer this approach to patients with anticipated benign pathology in whom a lobectomy only

**Fig. 3.** The robotic approach to the thyroid compartment has as the most appealing feature the complete elimination of a neck scar (A) by virtue of the remote access used (axillary). In addition, the technology affords a true three-dimensional view of the field (B), tremor filtration, and wristed instrumentation. The black arrow indicates the recurrent laryngeal nerve, passing just deep to the inferior thyroid artery (white arrow).
has been recommended, and we have combined it with laryngeal nerve monitoring to add a measure of safety. The early results have been satisfactory.

**SUMMARY**

After nearly a century of performing thyroidectomy essentially the way it was described by Theodore Kocher in the nineteenth century, the technique has quickly evolved. Parathyroidectomy has advanced as biochemical assays and physiologic imaging have become available. Minimally invasive and endoscopic thyroidectomy and parathyroidectomy can now be performed in many patients who benefit from the reduced dissection and smaller incisions associated with these approaches. Although many of the cosmetic, quality of life, and functional improvements have been proved, a better understanding of the procedure and the appropriate indications for its application will continue to develop even as the technique itself evolves, and as new approaches emerge.

**REFERENCES**


