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Robotic Neck Surgery in the Pediatric Population

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ABSTRACT

Introduction: Thyroid, parathyroid, and thymus surgeries are traditionally performed via a cervical approach. However, robot-assisted procedures can provide a safe alternative for neck surgeries. We report our experiences with robotic transaxillary and retroauricular approaches in pediatric patients.

Case Presentation: We conducted a retrospective review of pediatric patients who underwent robot-assisted neck surgery by a single surgeon between April 2010 and May 2017. Patient demographics and surgical outcomes including operative time, incidence of complications, and length of hospital stay were evaluated.

Management and Outcomes: Nine surgeries in 7 female patients were reviewed (mean age, 16.0 ± 1.58 years; mean body mass index, 22.5 ± 0.75). Two thyroid lobectomies, 2 complete thyroidectomies, 1 subtotal thyroidectomy, 1 thyroid lobectomy with thymectomy, 2 subtotal parathyroidectomies with thymectomy, and 1 dermoid cyst excision were performed. Two surgeries with the retroauricular approach had a mean surgical time of 142.0 ± 6.13 minutes. Seven surgeries with the transaxillary approach had a mean surgical time of 146.1 ± 21.01 minutes. There were no reported conversions, permanent vocal cord paralysis, permanent hypoparathyroidism, hematoma, or seroma. There was 1 case (11%) of temporary shoulder hypoesthesia and 2 cases of temporary vocal cord paresis (22%).

Discussion: This series on robot-assisted neck surgeries in children describes procedures performed with robotic transaxillary and retroauricular approaches. In the hands of a high-volume surgeon the techniques are feasible and safe options for operations in the neck in a select group of pediatric patients.

Key Words: Pediatric neck surgery, Retroauricular approach, Robotic surgery, Robotic pediatric surgery, Transaxillary approach.

INTRODUCTION

Thyroid, parathyroid, and thymus surgeries are traditionally performed via a cervical approach. However, with advancements in robotic and endoscopic technology, robot-assisted remote approaches can provide a safe alternative with a better cosmetic outcome. Gagner[1] first described endoscopic parathyroidectomy about 20 years ago. Since then, endoscopic techniques have advanced to a variety of distant and remote access approaches including the breast, transaxillary, and postauricular–axillary approaches.[2–4]

The transaxillary approach to the neck gives surgeons the ability to hide an incision in the axillary fold. In 2012, our group reported the largest series of robot-assisted transaxillary thyroidectomy without gas insufflation in the United States and showed that the approach was feasible and safe.[5] This approach has allowed surgeons to adopt high-definition cameras that provide tremor-free, 3-dimensional views previously unachievable with traditional endoscopic techniques. In addition, multiarticulated manipulating arms can fit in deep recesses during neck surgery to provide better dexterity. Our group also described a robotic retroauricular approach for both thyroid and parathyroid surgeries, allowing the incision to be hidden behind the ear.[6,7] Both transaxillary and retroauricular techniques are safe surgical options and provide better cosmetic outcomes by avoiding a visible central neck incision. A systematic review by Pan et al[8] also found that robotic thyroidectomy had less blood loss and a lower level of swallowing impairment when compared to open thyroidectomy.

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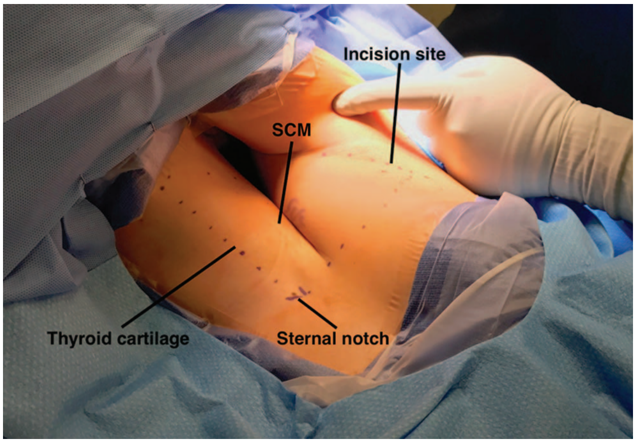

Figure 1. Robot-assisted transaxillary approach landmarks. The patient's arm is positioned over the head and flexed. The incision is made in the axilla, and dissection proceeds medially toward the neck to create a myocutaneous pectoral flap for robot docking.

However, robotic neck surgery has been more slowly adopted in the United States than in Asia. Differences in the United States patient population, particularly the higher prevalence of overweight and obese individuals in the United States than in Asia, may create difficulties in flap creation and exposure, deterring surgeons from pursuing a robot-assisted approach. However, our group has shown that experience, positioning, and instrumental compensation can overcome this limitation, resulting in no significant difference in complications between obese and normal-weight patients.[5] Higher cost and a lengthy learning curve associated with robot-assisted approaches have also limited their use, but our group has shown that with increased experience, shorter operative times can lead to lower operative costs.[5,9] Both the operating team and surgeon must be familiar with the equipment and the unique anatomic perspective of the operating field to optimize results. Current recommendations encourage robot-assisted approaches to be conducted by high-volume surgeons with consistent surgical team members.[5,7]

Surgery in children also poses unique challenges. Because of the smaller body size of the pediatric population, there are limited operative workspaces, particularly when considering remote robot-assisted surgical approaches.[10] In addition, the psychosocial impact of surgery and subsequent scarring in pediatric patients is often underdiagnosed and underreported.[11,12] Social stigmatization among peers can have significant consequences for an individual's social interactions and future employment opportunities.[11,13] Transaxillary and retroauricular approaches have been shown to result in increased cosmetic satisfaction relative to open cervical approaches in adults.[14,15] Less visible scars offered by remote approaches may decrease the psychosocial impact, especially in the pediatric population, that may result from visible scars.

We reviewed our experiences with robotic transaxillary and retroauricular approaches for neck surgery in 9 pediatric cases to assess the feasibility and safety of this approach in children.

CASE DESCRIPTIONS

A retrospective analysis and review of our surgical experience with retroauricular and transaxillary robot-assisted

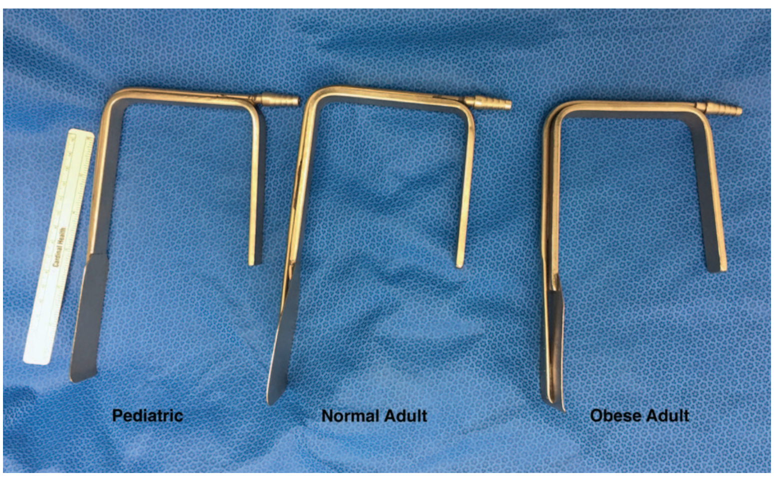

Figure 2. Retractors for robot-assisted transaxillary approach. A modified retractor of lesser width was used to maintain elevation of the myocutaneous pectoral flap in pediatric patients to provide an operative space during the robotic portion of the case.

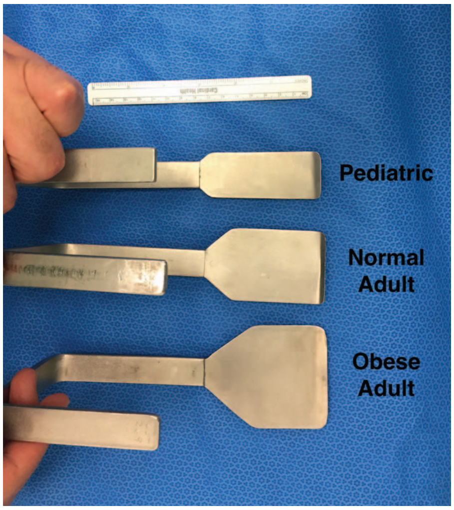

Figure 3. Additional view of retractors for robot-assisted transaxillary approach demonstrates width of pediatric retractor in comparison to standard retractor and retractor for obese patients.

neck surgery in patients 20 years of age and younger was completed. All cases were performed by a single high-volume surgeon at Tulane Medical Center between April 2010 and May 2017. All neck masses were evaluated before surgery by clinical evaluation and ultrasound examination. Patients with thyroid nodules underwent fine-needle aspiration biopsy according to American Thyroid Association guidelines.[16]

Patient records were evaluated for demographics, operative time, perioperative complications, intraoperative blood loss, use of intraoperative nerve monitoring, immediate postoperative complications, length of hospital stay, perioperative surgical outcomes, and final pathologic diagnosis. All patients underwent preoperative and immediate postoperative flexible fiberoptic laryngoscopy to evaluate recurrent laryngeal nerve function. All data are expressed as mean ± SEM, unless otherwise stated.

The transaxillary approach was performed as described in Kandil et al[5] and Kang et al[17] (**Figure 1**). A modified retractor with a smaller width than those used in adult patients was used to maintain elevation of the myocutaneous pectoral flap in the pediatric patients, to provide an operative space during the robotic portion of the case (**Figures 2** and **3**). The myocutaneous flap was dissected medially through the avascular plane between the sternal and clavicular heads of the sternocleidomastoid (**Figure 4**). The retroauricular approach was performed as described in Kandil et al.[18]

MANAGEMENT AND OUTCOMES

Between April 2010 and May 2017, 9 operations were performed in 7 pediatric patients (1 patient was 20 years

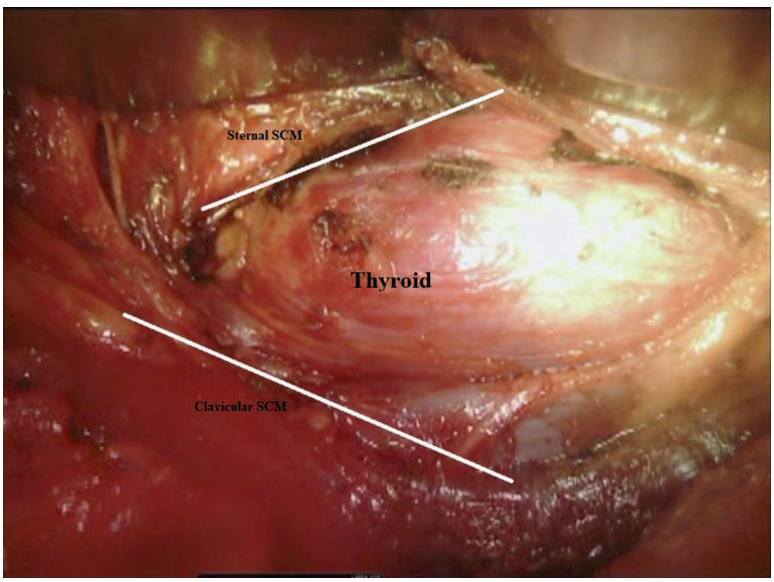

Figure 4. Representative image of the surgical working space via a transaxillary approach. The thyroid is accessed through the avascular space between the sternal head of the sternocleidomastoid seen superiorly and the clavicular head of the sternocleidomastoid seen inferiorly.

of age, which was the threshold for pediatric patients in this series and reflects an expanded definition beyond the standard pediatric definition of 18 years of age) (**Table 1**). All patients were females with a mean age of 16.0 ± 1.58 years (**Table 2**). Mean body mass index (BMI) was 22.5 ± 0.75. There were 2 thyroid lobectomies, 2 completion thyroidectomies, 1 subtotal thyroidectomy, 1 thyroid lobectomy with thymectomy, 2 subtotal parathyroidectomies with thymectomy, and 1 excision of a dermoid cyst. Indications for surgery included symptomatic goiter (56%), malignancy (44%), hyperparathyroidism (22%), and dermoid cyst (11%).

Overall mean operative time for all cases was 145.2 ± 18.33 minutes (**Table 3**). One thyroid lobectomy and 1 completion thyroidectomy were completed via a retroauricular approach with a mean operative time of 142.0 ± 6.13 minutes. The other 7 surgeries were completed via a transaxillary approach with a mean operative time of 146.1 ± 21.01 minutes. Mean operative time of the 2 subtotal parathyroidectomy with thymectomy was 122.5 ± 15.50 minutes.

Intraoperative blood loss was minimal in all cases, with 20 ml being the most blood loss reported. Five patients (56%) were discharged home the same day of surgery, 3 (33%) were discharged after an overnight stay, and 1 (11%) was discharged after 2 d.

Four of the cases (44%) were associated with transient symptomatic hypocalcemia in which patients described mild tingling in their fingertips after surgery. Symptoms in all cases resolved with oral calcium supplementation by the initial follow-up visit 5 days after surgery. One patient (11%) had temporary hypoesthesia of the shoulder, and numbness resolved within 4 weeks after surgery.

One patient with Hashimoto's thyroiditis underwent a transaxillary subtotal thyroidectomy for a symptomatic substernal goiter and a subsequent retroauricular completion left thyroidectomy. She reported temporary hoarseness after both of her operations (22%). The hoarseness resolved 2 weeks after surgery and fully resolved within 4 weeks. Vocal cord examination via flexible laryngoscopy confirmed normal function of the vocal cords.

Another patient underwent a transaxillary completion thyroid lobectomy after initial transaxillary thyroid lobectomy confirmed papillary thyroid cancer. Postoperative thyroglobulin levels were 0.3. There were no complications from either operation.

Total operative time for the transaxillary approach decreased with increasing experience from 4.5 h for the first pediatric subtotal thyroidectomy to 1.5 h for a thyroid lobectomy 7 years later. Total operative time for the retroauricular approach also decreased from 2.5 to 2 h between the 2 cases. No operations were converted to open. Mean total follow-up time was 107 ± 22.18 days. There were no reported postoperative incidents of permanent vocal cord paralysis, brachial plexus neuropraxia, permanent hypoparathryoidism, hematoma, or seroma.

DISCUSSION

Endoscopic and robotic techniques for neck surgery, particularly thyroid and parathyroid operations, have advanced and evolved over the past 2 decades to develop remote access approaches that avoid visible neck scars associated with conventional cervical approaches and achieve more favorable cosmetic results. Relative to the use of robotic surgery in other areas of the body, robot-assisted surgery for the head and neck has been slower to be adopted because of the ease of exposure through open approaches. However, the literature has shown a variety of robotic approaches for head and neck surgery, including remote transaxillary, retroauricular, and transoral.[5–7,18–21]

Although robotic remote access has been used frequently in the adult population, reports of robotic surgery in the pediatric population, especially for head and neck surgeries, are limited. Lobe et al[22] first reported the robot-assisted transaxillary approach in 2 pediatric patients in 2005. Since then, transaxillary robotic approaches have been described for thyroid lobectomy, total thyroidectomy, and recurrent laryngeal nerve reinnervation.[17,22,23] In 2014, Kim et al[24] also described a retroauricular approach to remove a thyroglossal duct cyst in a 20-year-old patient with no intraoperative complications.

Our study describes a large series of pediatric patients (and one 20-year-old) who have undergone robot-assisted remote approaches for a variety of head and neck diseases. Robot-assisted transaxillary and retroauricular approaches in the pediatric population present the challenges of limited space, resulting in a narrow field of view seen similarly with robotic remote approaches for neck surgery in obese patients. All 9 of our patients had a BMI of 31 or under, limiting any additional exposure difficulties related to obesity. Our previous studies in adults showed no significant difference in complications between obese and normal patients but did increase the complexity of flap creation.[5] Overall, we achieved good results in all 9 cases, with no long-term complications including recurrent laryngeal nerve injury or brachial

Table 1.
Individual Case Characteristics

Patient	Age (years)	BMI	Sex	Indication	Approach	Procedure	Pathology	Operative time (min)	Complications
1a	13	20.8	F	Compressive symptoms secondary to Hashimoto's disease	Right transaxillary	Subtotal thyroidectomy	R thyroid lobe and L thyroid lobe with Hashimoto's thyroiditis	275	Transient hypocalcemia and hoarseness
1b	16	20.2	F	Compressive symptoms secondary to Hashimoto's disease	Left retroauricular	Completion thyroidectomy	L thyroid lobe with Hashimoto's thyroiditis; negative for malignancy	155	Transient hypocalcemia and hoarseness
2a	15	30.6	F	Thyroid mass suspicious for malignancy	Left transaxillary	Thyroid lobectomy	L thyroid lobe with papillary thyroid carcinoma, follicular variant; T1bNx	85	None
2b	15	30.6	F	Confirmed papillary thyroid carcinoma	Right transaxillary	Completion thyroidectomy	R thyroid lobe with benign thyroid tissue; negative for malignancy	111	None
3	18	20.8	F	Compressive symptoms secondary to Hashimoto's disease	Right retroauricular	Thyroid lobectomy	R thyroid lobe with nodular hyperplasia and thyroiditis; negative for malignancy	129	None
4	14	21.8	F	Thyroid mass suspicious for malignancy; thymus mass	Left transaxillary	Thyroid lobectomy+ thymectomy	Benign thyroid tissue; unremarkable thymic tissue	170	Transient hypocalcemia
5	15	20	F	Hyperparathyroidism	Left transaxillary	Parathyroidectomy+ thymectomy	Thymic tissue with adjacent hypercellular parathyroid gland	107	Transient hypocalcemia
6	20	20.6	F	Hyperparathyroidism; Family history of MEN1	Left transaxillary	Parathyroidectomy+ thymectomy	L inferior, L superior, R inferior parathyroid glands with nodular hyperplasia; benign thymus gland	138	None
7	18	17.4	F	Level 2 dermoid cyst	Left transaxillary	Excision of dermoid cyst	Dermoid cyst	137	Transient hypoesthesia of shoulder

F, female; L, left; MEN, multiple endocrine neoplasia; R, right.

Table 2.
Clinical Characteristics

Characteristic	Data
Gender	
Male, n (%)	0 (0)
Female, n (%)	9 (100)
Age, years ± SEM (range)	16 ± 1.58 (13–20)
BMI, kg/m^2 ± SEM (range)	22.5 ± 0.75 (17.4–30.6)
Operation type, n (%)	
Thyroid lobectomy	2 (22)
Completion thyroidectomy	2 (22)
Subtotal thyroidectomy	1 (11)
Thyroid lobectomy+thymectomy	1 (11)
Parathyroidectomy+thymectomy	2 (22)
Excision of dermoid cyst	1 (11)
Surgical indications, n (%)	
Symptomatic goiter	5 (56)
Malignancy	4 (44)
Hyperparathyroidism	2 (22)
Dermoid cyst	1 (11)

plexus injury. Most of our patients were discharged to home the day of the operation.

Our first pediatric case, involving a subtotal thyroidectomy via a transaxillary approach, had the longest operative time, most blood loss, and temporary hoarseness after surgery. However, this case was performed in the youngest patient with excision of a 27.4 cm^3 left thyroid lobe and a 24.2 cm^3 right thyroid lobe, the largest masses seen in the series. Subsequent thyroid operations entailed lobectomy or completion thyroidectomy and had shorter operative times.

Two of our patients underwent transaxillary thyroid lobectomy for suspicion of thyroid follicular neoplasm. After confirmation of papillary thyroid carcinoma in 1 of the patients, the patient proceeded with a completion thyroidectomy 3 months later via a transaxillary approach through the opposite axilla to avoid potential adhesions from her first transaxillary surgery.[25] The patient elected to undergo a second transaxillary surgery because of her satisfaction with the initial transaxillary surgery and desire to avoid a visible neck scar from a conventional cervical approach. However, oncologic principles must not be sacrificed for cosmetic satisfaction.[5] Thyroglobulin levels were measured and found to be undetectable after surgery, suggestive of successful removal of all thyroid tissue.

One of the advantages of robot-assisted transaxillary and retroauricular approaches is the greater cosmetic satisfaction associated with these approaches.[14,15] Postthyroidectomy scars have been shown to negatively affect the quality of life of patients.[26] When given a hypothetical diagnosis of thyroid cancer, most adults in the United States preferred transaxillary thyroidectomy over cervical thyroidectomy to avoid the visible scar from direct cervical approaches.[27] Pediatric patients are particularly susceptible to psychological and social sequelae of scars. Scar location and a patient's perspective of the scar have been shown to be more important in psychosocial outcomes than simply a scar's physical characteristics.[28,29] Hiding incisions in the axilla (**Figure 5**) or behind the ear, by using transaxillary and retroauricular approaches, respectively, may decrease the psychosocial impact that can

Table 3.
Surgical Outcomes

Outcome	Data
Operation time, min ± SEM (range)	
Transaxillary retroauricular	145.2 ± 18.33 (85–275)
Transaxillary (7 cases)	146.1 ± 21.01 (85–275)
Retroauricular (2 cases)	142.0 ± 6.13 (129–155)
Length of hospital stay, n (%)	
0 days	5 (56)
1 day	3 (33)
2 days	1 (11)
Follow-up time: days ± SEM (range)	
Transaxillary and retroauricular	107.0 ± 22.18 (14–214)
Transaxillary (7 cases)	97.9 ± 26.74 (14–214)
Retroauricular (2 cases)	139.0 ± 37.00 (102–176)
Postoperative complications, n (%)	
Transient hypocalcemia	4 (44)
Transient hoarseness	2 (22)
Transient hypoesthesia of shoulder	1 (11)
Postoperative pathology, n (%)	
Thyroiditis	3 (33)
Parathyroid hyperplasia	2 (22)
Benign	2 (22)
Papillary thyroid carcinoma	1 (11)
Dermoid cyst	1 (11)

Figure 5. Postoperative transaxillary incision. Incision from a transaxillary approach is well healed and hidden in the axilla 4 weeks after surgery.

result from visible scars in the pediatric population. All patients in our study were satisfied with the cosmetic appearance of the neck during follow-up.

Although our results show positive outcomes for robot-assisted remote approaches for neck operations in the pediatric population, the number of robotic cases in the pediatric population is limited. These operations were conducted by a single high-volume surgeon who regularly performs robot-assisted operations for neck diseases in adults, and the learning curve associated with robot-assisted transaxillary approaches for thyroidectomy has been estimated to be 45 cases.[5] Experience using robot-assisted approaches in this population is limited and may have a similarly high learning curve, as seen in surgeries in the adult population, especially for surgeons with limited robotic experience. Further study on a greater number of cases in pediatric patients is needed to determine generalizability of these approaches for experienced surgeons. Studies using more robust, quantitative measures of patient satisfaction regarding scar appearance and quality of life would also be useful in conducting a cost–benefit analysis of this procedure.

CONCLUSION

Our results show that robot-assisted transaxillary and retroauricular remote approaches in the hands of a high-volume surgeon may be feasible and safe options with good cosmetic outcomes for operations in the neck in a select group of pediatric patients. Although we have shown that these remote approaches can be used for several different neck diseases, studies are needed to further evaluate the benefits and limitations of these approaches in the pediatric population and assess their generalizability.

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