NOVEL THYROIDECTOMY DIFFICULTY SCALE CORRELATES WITH OPERATIVE TIMES

David F. Schneider, MD, MS, **Haggi Mazeh, MD**, **Sarah C. Oltmann, MD**, **Herbert Chen, MD, FACS**, and **Rebecca S. Sippel, MD, FACS**

Section of Endocrine Surgery, Department of Surgery, University of Wisconsin, Madison, WI

Abstract

Introduction—The aim of this study was to evaluate a new thyroidectomy difficulty scale (TDS) for its inter-rater agreement, correspondence with operative times, and correlation with complications.

Methods—We developed a four item, 20-point TDS. Following cases where two board-certified surgeons participated, each surgeon completed a TDS, blinded to the other's responses. Paired sets of TDS scores were compared. The relationship between operative time and TDS scores was analyzed with linear regression. Multiple regression evaluated the association of TDS scores and other clinical data with operative times.

Results—A total of 119 patients were scored using TDS. In this cohort, 22.7% suffered from hyperthyroidism, 37.8% experienced compressive symptoms, and 58.8% had cancer. The median total TDS score was 8, and both surgeons' total scores exhibited a high degree of correlation. 87.4% of both raters' total scores were within one point of each other. Patients with hyperthyroidism received higher median scores compared to euthyroid patients (10 vs. 8, p<0.01). Similarly, patients who suffered a complication had higher scores compared to those patients without complications (10 vs. 8, p= 0.04). TDS scores demonstrated a linear relationship with operative times ($R^2 = 0.36$, p<0.01, Figure 1). Cases with a score of 14 or greater took 41.0% longer compared to cases with scores of five or less (p<0.01). In multiple regression analysis, TDS scores independently predicted operative time (p<0.01).

Conclusion—The TDS is an accurate tool, and scores correlate with more difficult thyroidectomies as measured by complications and operative times.

Keywords

thyroidectomy; difficulty; operative time; hyperthyroidism

Introduction

During the late 19th and early 20th century, thyroidectomy was associated with a 50% mortality and equally high morbidity. This led many medical experts to consider thyroid

Corresponding Author: David F. Schneider, MD, MS, Department of Surgery, University of Wisconsin, K3/738 Clinical Science Center, 600 Highland Avenue, Madison, WI 53792, Phone: 608-263-1387, Fax: 608-263-7652, schneiderd@surgery.wisc.edu.

surgery barbaric. Samuel Gross referred to thyroidectomy as "horrid butchery," and it was banned by the French medical society due to its high mortality (1).

With the advent of aseptic technique and an improved understanding of thyroid physiology, thyroid surgery has become much safer. Theodor Kocher achieved a mortality rate of 1% and won the Nobel Prize in 1909 for advancing thyroid surgery (1). Today, thyroidectomy is associated with virtually zero mortality and an extremely low morbidity when performed by high volume surgeons (2–4). Yet, complications from thyroidectomy can be life-altering. These include injury to the recurrent laryngeal nerves causing hoarseness and dysphagia, injury to the parathyroid glands causing hypocalcemia, in addition to neck hematoma. Fortunately, the risk of permanent complications range from 1–2% in experienced hands (5, 6). Rates of temporary complications are much higher, but vary depending on the indication for thyroidectomy, patient factors, and concomitant lymph node dissection. For example, the reported rates of transient hypocalcemia after total thyroidectomy range from 5 to 22% (7–9).

Thyroid surgeons associate certain thyroid disease processes with a more difficult resection and higher complication rates. These include thyroidectomy for Graves' disease, Hashimoto's thyroiditis, thyromegaly, or widely invasive thyroid carcinomas (10–14). For example, transient complications range from 12 – 38% for patients with Hashimoto's thyroiditis (11, 12, 15), and 11–28% (10, 16, 17) for Graves' disease. Permanent complications are also reported to be higher in these subsets. Complication rates, blood loss, and operative time serve as surrogates for difficulty. Difficulty scales have been developed for other types of procedures, often as a means to quantify the learning curve (18–21). The notion of difficulty in thyroid surgery literature remains subjective, and is limited to case reports, opinion, and technique papers (22–26). Traditionally cited factors contributing to difficulty in thyroid surgery include increased vascularity, inflammation, friability, fibrosis, and large gland size (12, 13, 27).

Currently, there are no measures of thyroidectomy difficulty as there are for other operations. This requires a more objective measurement of difficulty and evidence-based identification of patient and disease factors associated with difficulty. The purpose of this study was to evaluate a novel thyroidectomy difficulty scale (TDS) for its inter-rater agreement, correspondence with operative times, and correlation with complications.

Methods

This was a prospective study performed at a single, tertiary care academic center between 2012–2013. We developed a four item (vascularity, friability, mobility/fibrosis, gland size), 20-point TDS where each item is graded on a scale from 1–5 (Figure 1). Following cases where two board-certified surgeons participated, each surgeon completed a TDS, blinded to the other's responses. Participating surgeons were at the fellowship level of training or attending faculty members. Paired sets of TDS scores were compared using Spearman's rank correlation coefficient and inter-rater agreement was evaluated with the kappa statistic. Patient co-morbidities, disease characteristics, and preoperative labs were obtained from an

existing endocrine surgery database. Operative times were obtained from the electronic medical record and calculated as the time from incision until wound closure.

Patients with any type of thyroid carcinoma greater than 1 cm on final histopathology were considered to have a diagnosis of cancer. Any patients with an undetectable TSH on preoperative labs or treated with anti-thyroid medications were considered to have hyperthyroidism. Compressive symptoms included pain or pressure in the neck, dysphagia, dysphonia, or respiratory symptoms. Complications included hoarseness, hypoparathyroidism, and neck hematoma. Hypoparathyroidism was defined as a PTH < 10 pg/ml. These complications were categorized as transient if they resolved within six months and permanent if they persisted beyond 6 months.

The relationship between operative time and TDS scores was analyzed with linear regression. Binary comparisons were made using the student's t-test, Chi-squared test, or the Mann-Whitney *U* test where appropriate. Multiple regression evaluated the association of TDS scores and other clinical data with operative times. All analyses were performed using STATA v. 12.1 (StataCorp, College Station, TX). The University of Wisconsin's Institutional Review Board approved this study.

Results

Pre-operative characteristics

There were 119 patients included in this study. The mean age was 51.6 ± 3.8 years, and 75.6% were female (Table 1). This cohort had a median of two co-morbidities, and 10.9% were current smokers. The thyroid pathology included hyperthyroidism (22.7%), Hashimoto's thyroiditis (20.2%), and thyroid cancer (21.0%), although these categories were not mutually exclusive (Table 1). 45 patients (37.8%) reported compressive symptoms from their thyroid disease (Table 1).

TDS Scores

The mean total TDS score was 8.6 with a range from 4 to 17 (Table 2). When examining the score profiles for patients with various thyroid pathologies, patients with hyperthyroidism tended to score higher in the vascularity (3.0 ± 1.1) and had the highest overall scores (10.0 ± 2.8, Table 2). Those with Hashimoto's thyroiditis tended to score higher in the mobility/fibrosis category (2.5 ± 1.1, Table 2). Compared to euthyroid patients, those with hyperthyroidism received higher median scores (10.1 vs. 8.1, p = 0.02).

Inter-rater agreement

For individual items on the TDS, exact agreement between surgeons ranged from 62.2 to 68.9%. Inter-rater agreement as measured by Cohen's Kappa (κ) ranged from 0.44 to 0.59, indicating moderate to good agreement between raters (Table 3). Importantly, the agreement was significantly better than chance alone for each item on the TDS (Table 3).

While the above measures account for instances where the two surgeons gave the exact same score, the two surgeons' scores correlated well, even if the two scores were not identical. Both surgeons' total scores exhibited a high degree of correlation (Spearman's rho

= 0.92, p<0.001). 87.4% of both raters' total scores were within one point of each other (Figure 2).

Correlation with Operative Time

TDS scores demonstrated a linear relationship with operative times ($R^2 = 0.36$, p<0.01, Figure 3). Cases with a score of 14 or greater took 41.0% longer compared to cases with scores of five or less (p<0.01).

In multiple regression analysis, TDS scores were independently associated with operative time when controlling for other clinical, laboratory, and patient factors (p<0.01). Preoperative thyroglobulin levels were also significant in this model (p<0.01).

Complications

There were 23 complications (19.33%) that occurred in this cohort. Of these 23 patients, 8 (34.8%) experienced temporary hoarseness, 14 (60.9%) had temporary hypocalcemia, and 1 patient (4.3%) was re-operated on for neck hematoma. None of the patients in this cohort experienced a permanent complication. Patients who suffered a complication had higher TDS scores compared to those patients without complications (10 vs. 8, p= 0.04). There was a step-wise increase in the percentage of complications as TDS scores increased (Figure 4).

Discussion

The TDS presented here had good inter-rater agreement for a variety of thyroid diseases. Importantly, TDS scores correlated with operative times and the number of complications. Therefore, TDS can serve as a useful tool to identify the patient and disease characteristics associated with a difficult thyroidectomy. This will enable future research on factors contributing to operative difficulty.

TDS is novel. Several difficulty scales exist for other operations such as laparoscopy, cataract surgery, or aneurysm repair (18, 19, 28). In thyroid surgery, literature on difficulty is somewhat sparse. The thyroid surgery literature does, however, include numerous examples of each individual item that comprises the TDS. For example, the benefit of Lugol's potassium iodide drops in decreasing the thyroid's vascularity and friability in Graves' disease is still debated (29, 30). Fibrosis, another component of the TDS, is seen in Hashimoto's thyroiditis, and contributes to higher complication rates (12). Finally, larger gland size contributes to higher complication rates, specifically airway complications and transient hypocalcemia (13, 15, 24). The TDS incorporates all of these aspects of difficulty —size, vascularity, friability, and gland size—to create a single composite score of difficulty.

Measuring difficulty is important since it correlated with increased complication rates (Figure 4). We have also shown that thyroidectomy was more difficult in patients with hyperthyroidism (Table 2). Since measurement of difficulty can only occur intra- or post-operatively, the surgeon cannot immediately use TDS as a preoperative prediction tool. Further analysis of the specific factors contributing to difficulty will allow improved preoperative risk counseling for patients undergoing thyroidectomy. In order to do this, we

first needed a valid, objective measurement of difficulty; this report supports the use of TDS as such a validated measure of difficulty. The next step in this research will be to identify preoperative lab values, medications, co-morbidities, or patient demographics that predict more difficult operations (higher TDS scores), and therefore, a greater chance for complications. Further study of the factors contributing to difficulty using the TDS tool can allow a more personalized assessment of the perioperative risks. TDS is a valuable tool that will allow this type of research.

TDS scores also correlated with operative times. If TDS can improve our understanding of the specific factors contributing to difficulty, then it can be used to better predict operative times. This is especially important as more thyroid surgeons perform thyroidectomy on an outpatient basis (6, 31). Increased efficiency and timeliness characterize most outpatient surgery centers (32). Future use of TDS can help identify cases that would require more time, and allow better appropriation of OR time. Safety of outpatient thyroidectomy remains a concern. Although there are newer methods for managing hypocalcemia as an outpatient (33, 34), safety of outpatient thyroidectomy is still questioned due to the risk of life-threatening neck hematoma (35, 36). Since TDS measures the degree of difficulty, and this score correlated with operative times and complications, future research can now use TDS scores to identify the patient and disease factors associated with greater difficulty, or higher risk.

Although much of the thyroid surgery literature uses operative time, blood loss, and complications as surrogates for difficulty (11, 13, 29, 37, 38), these items alone may not capture the entire notion of difficulty. For example, Consorti and colleagues examined the factors influencing operating time for total thyroidectomy. They found that factors such as thyroid volume or neck circumference explained very little of the variance in operative time (39). Increased gland size is traditionally viewed as a factor contributing to difficulty. Although the TDS did correlate with operative times, we tested the TDS on a variety of thyroid diseases, and the correlation would likely improve with a more homogenous cohort (Figure 3).

This study was performed at a high volume tertiary referral center. Although we did express operative time in relation to average time rather than actual minutes, these results along with the complication rates may not be generalizable to other centers, especially those with less thyroid volume. We also recognize that the specific ratings in each category remain somewhat subjective despite providing guidelines and examples for each range of scores (Figure 1). Since this cohort only included cases where two surgeons of at least the fellow level participated, it may be biased toward more difficult cases. Validation by other institutions will determine if TDS applies to a wide case mix. The range of disease processes and scores implies that this cohort included a range of diseases and difficulty level.

TDS is a novel tool with high inter-rater agreement for scoring the difficulty of thyroid operations. Since TDS scores correlated with operative times and complications, TDS can be utilized in future research to identify risk factors for more difficult, risky, and lengthier cases.

Acknowledgments

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THYROIDECTOMY DIFFICULTY SCALE (TDS)

Patient Name/MR _____

Surgeon _____

Date of Surgery _____

Vacularity   1   2   3   4   5

                       Normal   moderate   extensive

Friability   1   2   3   4   5

Easy to retract   Tears easily but able to retract   Unable to hold with any clamp
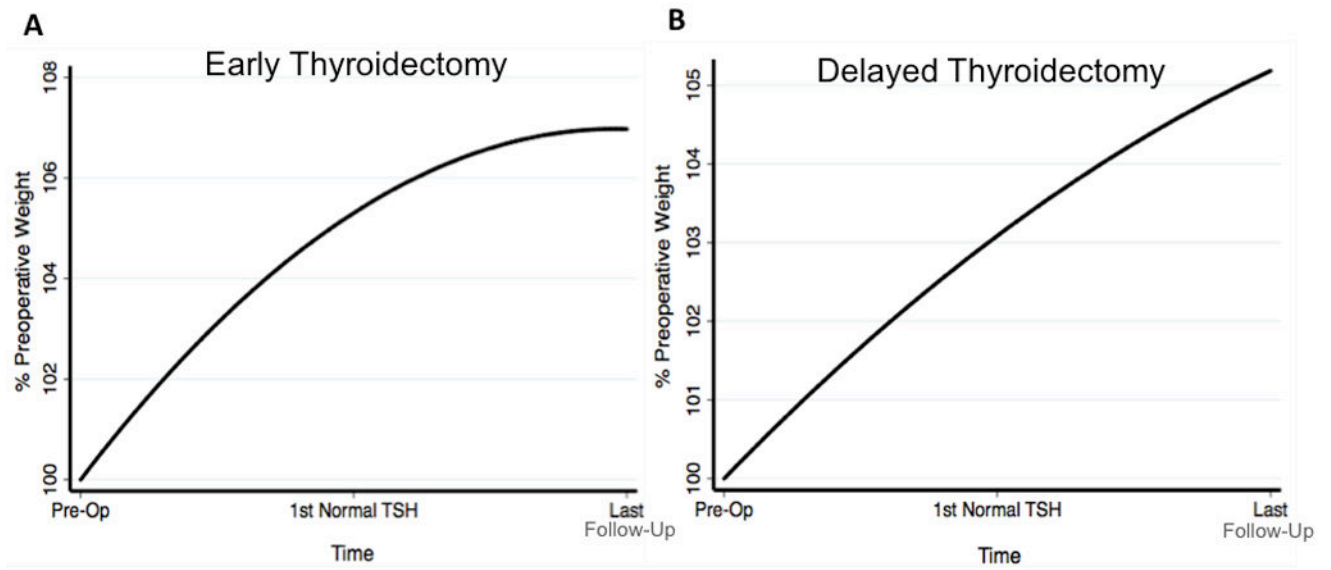
Mobility/fibrosis   1   2   3   4   5

Elevates easily   Able to retract medially with effort Fixed in position/unable to retract

Gland Size   1   2   3   4   5

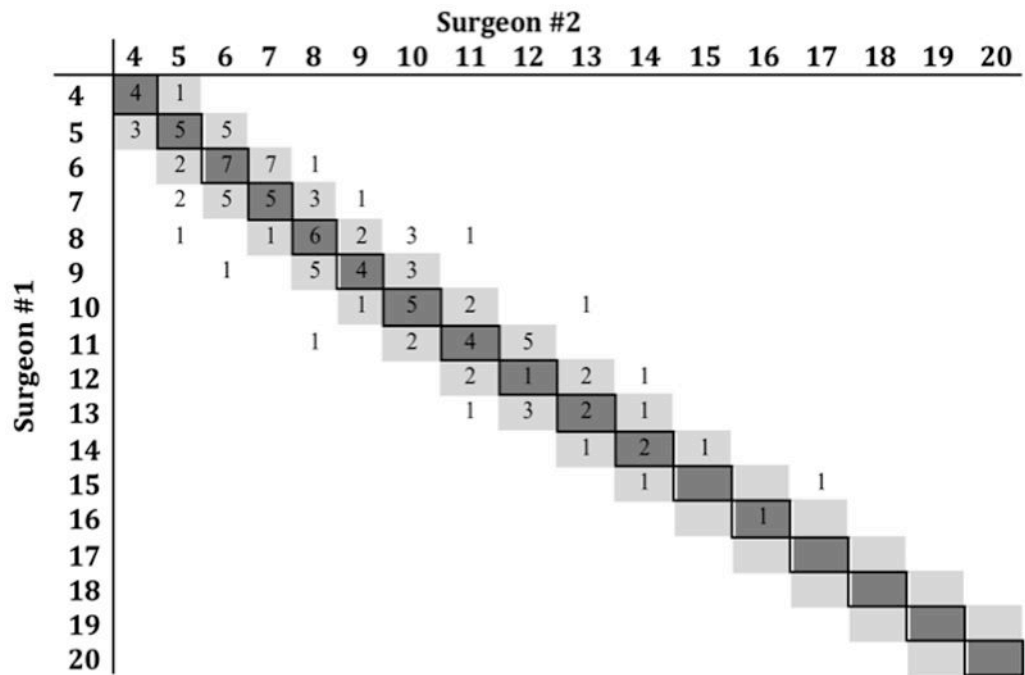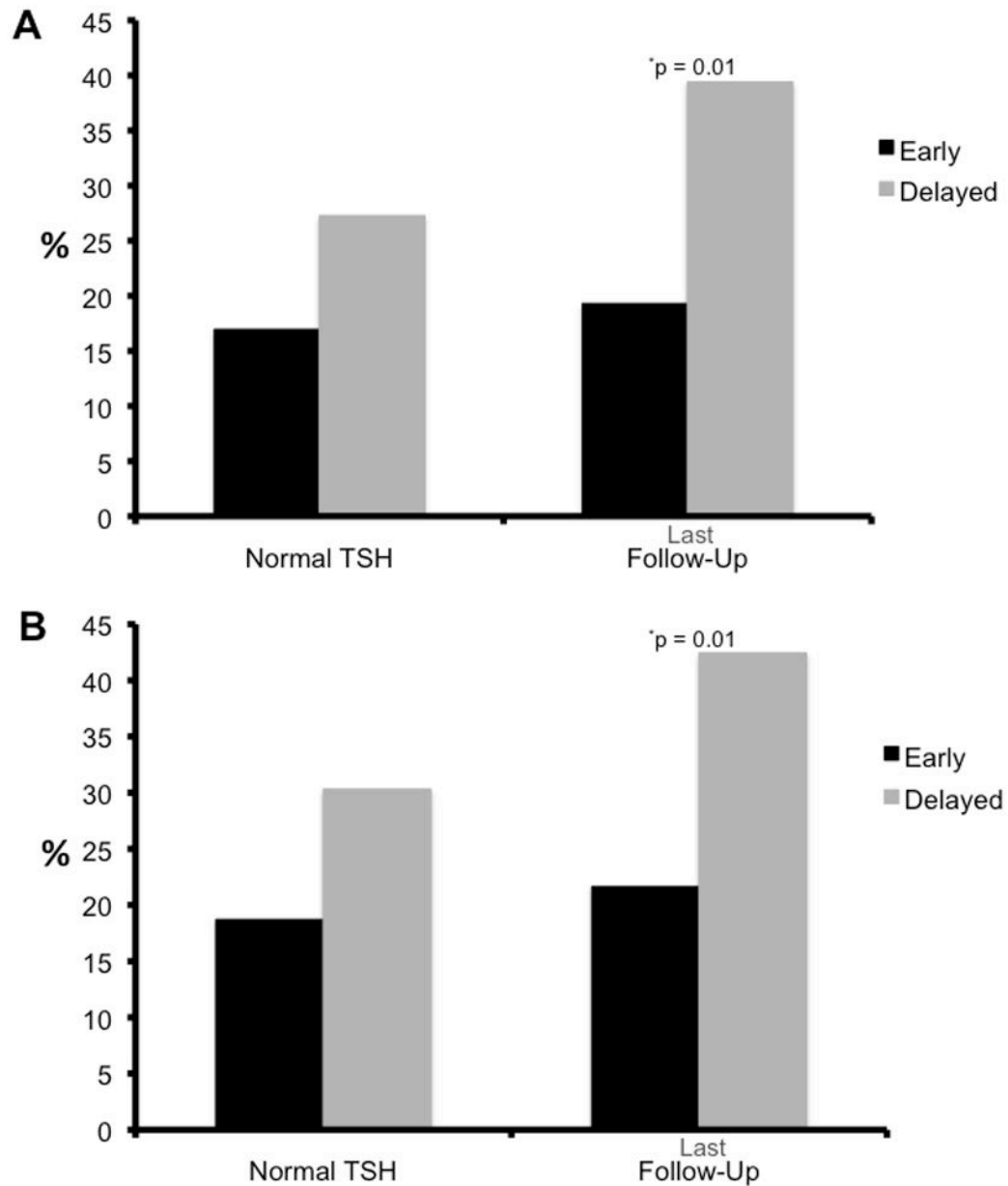   Normal size   above average size   large/goiter

Point Total _____

Comments:

Figure 1. Thyroidectomy Difficulty Scale (TDS)
Scoring sheet for the Thyroidectomy Difficulty Scale (TDS).

Surgeon #2

| Surgeon #1	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
4	4	1															
5	3	5	5														
6		2	7	7	1												
7		2	5	5	3	1											
8		1		1	6	2	3	1									
9			1		5	4	3										
10						1	5	2		1							
11					1		2	4	5								
12								2	1	2	1						
13								1	3	2	1						
14										1	2	1					
15											1			1			
16												1					
17																	
18																	
19																	
20																	

Figure 2. Cross Tabulation of Each Surgeon's TDS Scores
Cells with dark shading indicate exact correlation while lighter shaded cells indicate scores within one point of each other. Numbers in each cell indicate the number of patients with each set of scores.
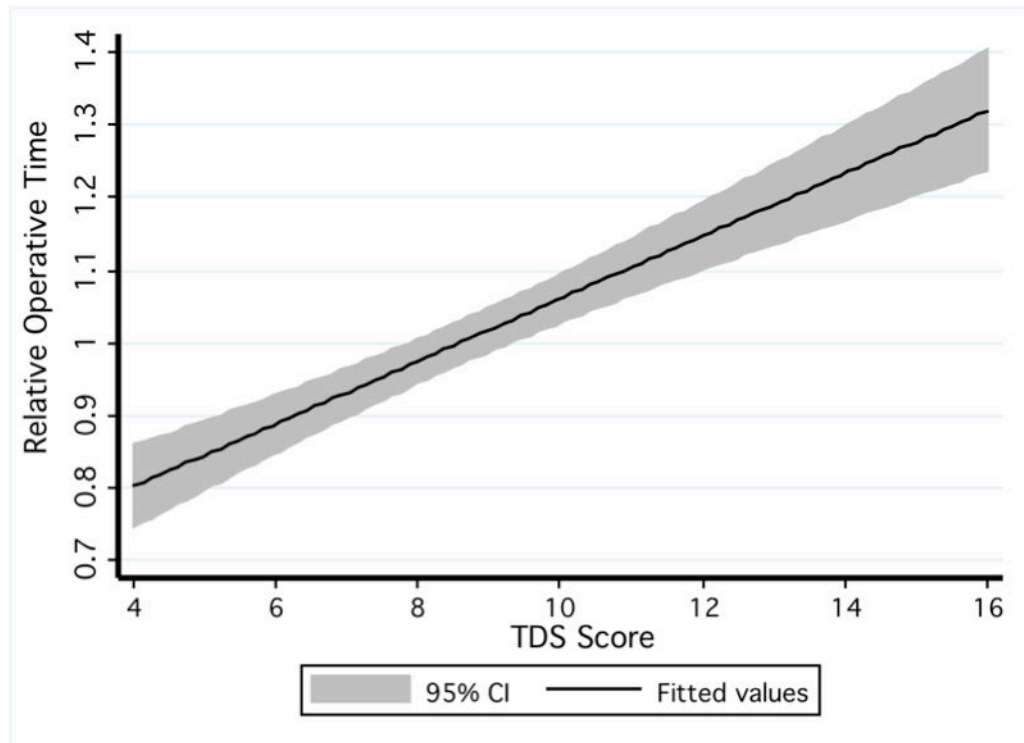
Figure 3. TDS Scores Correlate with Operative Time
The line represents the linear regression between TDS scores and the adjusted operative times. The shaded area indicates the 95% confidence interval for the regression equation.
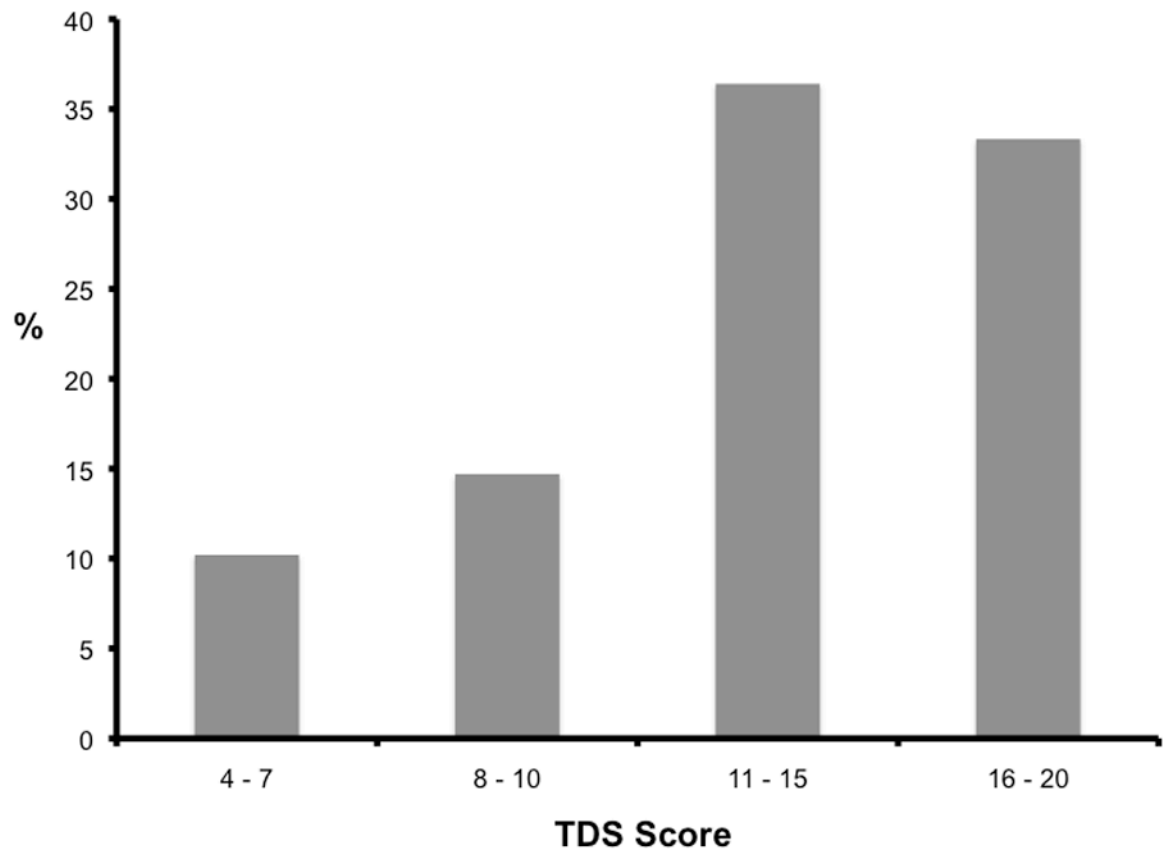
Figure 4. TDS Scores Correlate with Complications
The percentage of complications within each Thyroidectomy Difficulty Scale (TDS) score range is shown.

Table 1

Patient Characteristics (n = 119)

Variable	Number (%)
Age	51.6 ± 3.8
Female	90 (75.6%)
BMI (kg/m^2)	29.5 ± 2.6
Smoker	13 (10.9)
Pregnant	1 (0.8%)
Median # co-morbidities	2 ± 1
Cancer	25 (21.0%)
Hyperthyroidism	27 (22.7%)
Hashimoto's thyroiditis	24 (20.2%)
Compressive symptoms	45 (37.8%)

Data are expressed as a mean ± standard error of the mean for continuous variables and the count with the percentage in parentheses for categorical variables. The categories cancer, hyperthyroidism, Hashimoto's thyroiditis are not mutually exclusive.

BMI = body mass index

Table 2

TDS Scores

TDS Item	Mean Score	Standard Deviation
Overall Cohort		
Vascularity	2.2	1.1
Friability	1.9	1.0
Mobility/Fibrosis	2.0	1.0
Gland Size	2.5	1.1
Total Score	8.6	2.9
Hashimoto's		
Vascularity	2.3	1.1
Friability	1.7	0.8
Mobility/Fibrosis	2.5	1.1
Gland Size	2.1	0.9
Total Score	8.5	3.1
Hyperthyroidism		
Vascularity	3.0	1.1
Friability	2.5	1.0
Mobility/Fibrosis	2.2	1.0
Gland Size	2.5	0.9
Total Score	10.0	2.8

Table 3

Inter-Rater Agreement

TDS Item	Median Score	Agreement (%)	Expected Agreement (%)	Inter-Rater Agreement (κ)	p
Vascularity	3	62.2	26.7	0.48	<0.01
Friability	1	62.2	32.5	0.44	<0.01
Mobility/Fibrosis	2	63.1	30.2	0.46	<0.01
Gland Size	3	68.9	24.1	0.59	<0.01

For each item on the TDS scale, the average score between the two surgeons is displayed along with measures of agreement. Cohen's kappa (κ) is a statistic that evaluates the agreement between two raters where zero indicates an agreement no better than chance and 1 indicates perfect agreement. Also displayed is the percentage of exact agreement (i.e, the exact same score) and the percentage of expected agreement due to chance alone.

TDS = thyroidectomy difficulty scale