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Original Article

Intercostal nerve reconstruction for compensatory hyperhidrosis: clinical outcomes of the "Gebitekin technique"

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ABSTRACT

Background: Compensatory hyperhidrosis (CH) is the most common complication following endoscopic thoracic sympathectomy (ETS) and significantly impairs quality of life (QOL). This study assesses and compares the QOL before and after our minimal invasive intercostal nerve reconstruction technique (the "Gebitekin Technique", GT) in CH patients.

Materials and Methods: Between January 2014 and November 2016, 32 consecutive CH patients underwent GT. Patients' satisfaction levels and demographic parameters were self-assessed before surgery and six months postoperatively using the World Health Organization Quality of Life questionnaire (WHOQOL-BREF) and institutional questionnaires.

Results: A total of 64 surgeries were performed in 32 patients with a mean age of 32.5 ± 6.77 years. All patients who underwent GT responded to the questionnaires. Improvement of CH symptoms was observed in 24 (75%) patients, along with improvement in dryness in 60%. None of the patients had recurrence of primary hyperhidrosis. Significant ($p < 0.05$) improvements were observed in all survey sub-areas following surgery.

Conclusion: This study demonstrates that GT improves QOL and alleviates related symptoms in the overwhelming majority of patients with CH.

Keywords: compensatory hyperhidrosis, intercostal nerve reconstruction, survey, quality of life, Gebitekin technique

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Introduction

Primary focal hyperhidrosis (PFH) involves the hands, feet, face, and/or axilla, with a prevalence ranging from 1% to 3% [1]. When medical treatment fails, endoscopic thoracic sympathectomy (ETS) represents the standard therapeutic option. The presence of the 'Kuntz nerve' - an alternative pathway running parallel to the sympathetic chain between the T1 and T2 levels - constitutes an important cause of failure [2]. Compensatory hyperhidrosis (CH) - defined as excessive sweating in anatomical regions where previously there was no significant sweating - may be observed in 3% to 98% of cases [1]. Once it develops, CH greatly impairs patients' quality of life (QOL), and medical treatments usually fail [3]. Promising results of surgical sympathetic pathway reconstruction have been reported lately [4].

A novel intercostal-to-intercostal nerve reconstruction technique, termed the "Gebitekin Technique" (GT), has been developed to create an alternative pathway to the sympathetic chain through the intercostal nerves, thereby potentially reducing the likelihood of CH [5].

This study aimed to compare pre- and postoperative QOL and patient satisfaction following treatment of CH using the GT.

Materials and Methods

This prospective study was conducted at the Department of Thoracic Surgery, Uludag University, between January 2014 and November 2016, following the approval of the institutional ethics committee. Patients who developed compensatory hyperhidrosis were informed in detail about the 'Gebitekin Technique' (GT). Surgical treatment was performed on those who consented to the procedure. Data analysis was conducted for this patient cohort after a follow-up period of two years."

The decision to operate was based on complaints and symptoms that adversely affected daily or social life and impaired QOL. Written informed consent was obtained from all patients. All patients undergoing surgery completed, both preoperatively and 6 months postoperatively, the WHO Quality of Life Scale-Short Form (WHOQOL-BREF) and a second in-hospital questionnaire, which was based on and extended the WHOQOL-BREF questions. For example, patients were asked, "How much does your sweating prevent you from accomplishing your daily tasks?" and instructed to provide a score between 1 and 5 (1 = none, 5 = greatly).

The "Gebitekin Technique"

The technique involves creating an end-to-end anastomosis between the two intercostal nerves located proximal and distal to the sympathetic chain levels previously cut or clipped during ETS.

Under general anesthesia with double-lumen intubation, the patient is placed in the lateral decubitus position, and surgery is performed using biportal videothoracoscopy. The intercostal nerves above and below the level of the previous cutting or clipping are dissected without cautery and then divided. If present, clips are removed after intercostal nerve dissection (Figure 1).

The prepared intercostal nerves are approximated end-to-end using one or two interrupted 5/0 polydioxanone sutures (PDS), avoiding direct manipulation of the nerves. The anastomosis is then inspected and secured to the pleural surface with fibrin glue (Figure 1) [5]. After achieving hemostasis, a 16–20F chest drain is inserted into the pleural cavity. During the same session, the technique is repeated on the contralateral hemithorax.

WHOQOL-BREF Survey / Questionnaire and Analysis Assessment

The WHOQOL-BREF questionnaire [6–8] was re-administered after six months, together with an in-house questionnaire assessing patients' satisfaction levels. In addition, the question "How much does your sweating prevent you from accomplishing your daily tasks?" was re-administered.

Quality of life (QOL) was measured using the Turkish version of the WHOQOL-BREF (WHOQOL-BREF-TR). The validity and reliability of the Turkish version of the WHOQOL-BREF were established by Eser et al [9]. The WHOQOL-BREF-TR questionnaire is presented in Table 1.

The study was approved by the Uludag University Ethics Committee (03/2017-4/41) and the Institutional Review Board. Written informed consent was obtained from all patients, including consent for the use of their anonymized data for research and publication purposes, in accordance with the principles of the Declaration of Helsinki.

Table 1. WHOQOL-BREF domains.	
Domain	Facets incorporated within domains
1. Physical health	Activities of daily living Dependence on medication and medical aids Energy and fatigue Mobility Pain and discomfort Sleep and rest Work capacity
2. Psychological	Bodily image and appearance Negative feelings Positive feelings Self-esteem Spirituality / Religion / Personal beliefs Thinking, learning, memory and concentration
3. Social relationships	Personal relationships Social support Sexual activity
4. Environment	Financial resources Freedom, physical safety and security Health and social care accessibility and quality Home environment / Transport Opportunities for acquiring new information and skills Participation in, and opportunities for, recreation and leisure activities Physical environment (pollution / noise / traffic / climate)

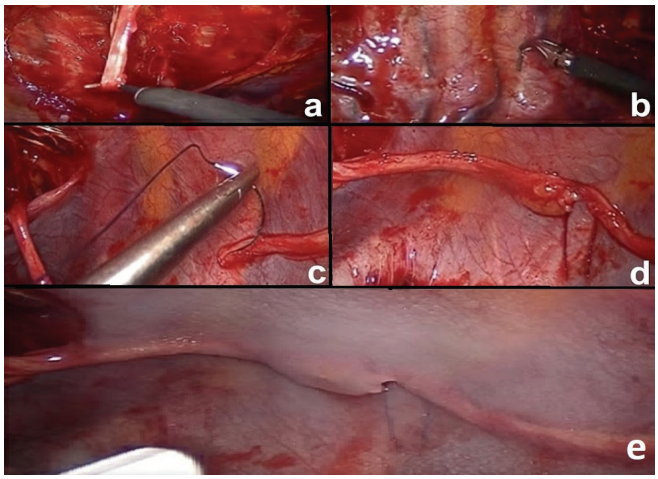

Figure 1. Intraoperative view of the Gebitekin Technique. Intercostal nerve dissection. An endoscopic clamp is used to push the clip downward to pass the pleura, clips are removed from the closed end using an endoscopic clamp **(a,b)**, nerve anastomosis is performed using PDS sutures **(c,d)**, intercostal nerves are supported with fibrin glue after end-to-end anastomosis **(e)**.

Statistical Analysis

The normality of variable distribution was tested using the Shapiro–Wilk test, and results were expressed as mean ± standard deviation (SD). An independent samples t-test was used to compare two independent groups, and a paired samples t-test was used to compare two dependent groups. The Mann–Whitney U test was used to compare two independent groups, the Wilcoxon signed-rank test was used to compare two dependent groups. Categorical variables were expressed as frequencies and percentages (n, %), and compared using the Pearson chi-square test or Fisher's exact test. Relationships between variables were examined using Spearman's correlation coefficient. Statistical analyses were performed using SPSS Statistics version 22.0, and ROC analysis was conducted with MedCalc version 12.3.0.0. A p-value of <0.05 was considered statistically significant.

Results

A total of 36 patients were evaluated. Thirty-two patients constituted the study group, as four were excluded due to failed intercostal-to-sympathetic nerve anastomosis surgery, resulting in 32 VATS GT procedures. These patients formed the basis of the QOL assessment. The study group consisted of 23 males (72%) and nine females, with a mean age of 32.5 ± 6.77 years (Table 2).

Facial sweating was the most common indication for ETS (12/32, 37.5%). ETS was limited to one level in 11 patients (34.3%), and 14 patients (43.7%) underwent ETS with clipping. The median interval between ETS and GT was 48 months (range: 8–192) (Table 2).

Multifocal CH was observed within the first month after surgery in 23 patients (71.8%). Severe CH was present in all but two patients and was accompanied by excessive dryness, depression, fatigue, loss of excitement, loss of libido, and upper extremity weakness in 23 patients (71.8%). Excessive dryness at the PFH site was observed in 15 patients (46.8%). Fifty percent of the patients had previously received medical treatment.

Preoperatively, patients were asked to rate their complaints on a scale of 1 to 5 (1 = none, 5 = severe) and to indicate whether they regretted undergoing the ETS

operation and how much CH affected their daily lives. All but two patients (2/32, 93.8%) regretted undergoing ETS, and 84% (n = 27) stated that their daily lives were severely limited by CH.

The preoperative WHOQOL-BREF questionnaire showed that 26 patients (81.2%) reported having poor QOL, and none of the patients (100%) were satisfied with their QOL. Fourteen patients (43.75%) reported being dissatisfied with their health (Question 2). Six patients also reported complaints regarding their sexual life.

All but one patient underwent bilateral nerve surgery in the same surgical session using two-port videothoracoscopy. The mean duration of anesthesia for bilateral operations was 165.16 minutes (range: 100–255). In fifteen patients (43.7%), the first intercostal nerve was used for anastomosis.

Hemothorax occurred in four patients (4/32, 12.5%), who were treated with VATS exploration within 24 hours postoperatively. Late complications included areolar hyperaesthesia in three patients and a keloid scar in one patient. In addition, hypoesthesia was observed in 13 patients in the corresponding area of the intercostal nerve used for anastomosis. All complaints, except for nipple hyperaesthesia observed in two patients, were transient and subsided within 6 months after surgery.

Twenty-four patients (75%) reported a reduction in CH. The median decrease in CH among all patients was 20% (range: 0–70%). In the ROC analysis, it was found that a 12.5% decrease in CH was associated with a reduction in the number of daily clothing changes reported by patients. The area under the ROC curve (AUC) was found to be statistically significant ($p < 0.0001$) in this analysis. In addition, the reduction in CH was not affected by the timing of GT ($p = 0.661$).

In the postoperative period, patients were asked about the regression rate after GT and the degree to which CH affected their daily lives, which decreased from 84% (n = 27) to 31.3% (n = 10) ($p < 0.01$). Only four patients (12.5%) regretted undergoing the GT operation. The number of daily clothing changes decreased in 19 patients (59.4%) ($p < 0.01$). Eighteen patients (56.2%) recommended GT, and six patients (18.7%) were indecisive.

There was similar reliability between the preoperative and 6-month postoperative WHOQOL-BREF-TR questionnaires (Cronbach's alpha coefficients: 0.891 and 0.925, respectively), and no statistical significance was observed among other preoperative variables studied. However, the improvement in symptoms after GT was statistically significant in patients who had previously undergone a T2 block with ETS ($p = 0.041$). In other words, when intercostal nerve reconstruction was performed, recovery rates were significantly better in patients in whom the T1 nerve was used ($p = 0.041$) (Table 3).

When the domains of health in the preoperative WHOQOL-BREF questionnaire were examined, the domain most affected by CH was the psychological subgroup (mean score: 10.21, range: 4–17.33). The next lowest score was in the social health subgroup, with a mean score of 11.83 (range: 4–20) (Table 4).

The results of the WHOQOL-BREF questionnaire, which was re-administered postoperatively, identified 16 patients (50%) who reported that their quality of life was good or very good (4 or 5 points). In the postoperative period, the number of patients requiring extensive medical treatment (5 points) for their complaints decreased to seven. The number of patients dissatisfied with their sexual life and those not satisfied with their health both declined to three, respectively. When the percentage changes in the preoperative and postoperative survey subdomains were compared, the questions showing the greatest variation were questions 4, 1, and 2, respectively.

The statistical evaluation of the WHOQOL-BREF questionnaire was based on percentage changes. The calculation was performed as follows: Percentage change = (postoperative value – preoperative value) / preoperative value.

Percentage change scores for the WHOQOL-BREF subdomains are summarized in Table 5. Patients with ≥ 4 hyperhidrosis regions showed significantly greater improvements in physical health ($p = 0.018$) and environmental health ($p = 0.03$) compared with those with ≤ 3 regions, whereas no differences were observed in the psychological or social domains. When comparing

ETS methods, patients treated with clips demonstrated a greater median improvement in physical health scores compared with those treated with cautery or dissection (p = 0.045). In addition, patients who reported postoperative sweating or moistening at the initial ETS sites showed significantly greater improvements in physical health compared with those without such symptoms (p = 0.029).

Twenty-four patients (75%) reported a reduction in reflex sweating. The median decrease in reflex sweating across all patients was 20% (range: 0–70). In the ROC analysis performed to determine a cut-off value at which the reduction in sweating percentage would correspond to a decrease in the number of daily clothing changes, it was found that a 12.5% reduction in reflex sweating was associated with fewer clothing changes. As the p-value was <0.0001, the area under the ROC curve (AUC) was considered statistically significant. At the 6-month postoperative follow-up, patients were asked to what extent their CH symptoms were reduced, and the ROC analysis was conducted based on their responses. Patients were divided into two groups: those with a reduction of < 12.5% in CH and those with ≥ 12.5%. There was a statistically significant percentage change when the physical and psychological subdomains of the WHOQOL-BREF questionnaire were compared between these groups (pPA = 0.006, pPSA = 0.009, pSA = 0.022, pEA = 0.223).

Table 2. Patients demographical information.

Variable		*n (%)
Age (years)		32.09±6.77
Sex	Female	9 (28.13%)
	Male	23 (71.88%)
Marital status	Single	20 (62.50%)
	Married	10 (31.25%)
	Divorced	2 (6.25%)
Occupation	Social	11 (34.38%)
	Requires effort	8 (25.00%)
	Others	13 (40.63%)
Education level	Elementary	1 (3.13%)
	High school	6 (18.75%)
	Associate	7 (21.88%)
	Undergraduate	16 (50%)
	Postgraduate	2 (6.25%)
ETS etiology	Single region hyperhidrosis	19 (59.38%)
	Hyperhidrosis in more than 1 region	13 (40.63%)
	Facial sweating and flushing	12 (37.5%)
ETS method	Clipping	14 (43.75%)
	Cautery/Dissection	18 (56.25%)
ETS anatomic level	Single level block	11 (34.38%)
	Block in more than 1 level	21 (65.62%)
Number of compensatory hyperhidrosis regions	≤3	15 (46.88%)
	≥4	17 (53.13%)
Time interval between the two surgeries	<48 months	14 (43.75%)
		18 (56.25%)

ETS: Endoscopic thoracic sympathectomy, n: number of patients

Table 3. Comparison of the variables between two groups (patients with a reduction in compensatory sweating symptoms after GT/patients with no change in symptoms after GT).				
Variables		No change in symptoms (n=8)	Reduced symptoms (n=24)	p-value
Age* (min-max)		30.63 (24-41)	32.58 (22-48)	0.487
Sex	Female	3 (33.3%)	6 (66.7%)	0.654
	Male	5 (21.7%)	18 (78.3%)	
Marital Status	Single	4 (18.2%)	18 (81.8%)	0.218
	Married	4 (40.0%)	6 (60.0%)	
Occupation	Social	3 (27.3%)	8 (72.7%)	1.000
	Requiring effort	2 (25.0%)	6 (75.0%)	
	Others	3 (23.1%)	10 (76.9%)	
Education Level	Elementary	0 (0.0%)	1 (100.0%)	0.359
	High school	0 (0.0%)	6 (100.0%)	
	Associate	3 (42.9%)	4 (57.1%)	
	Undergraduate	4 (25.0%)	12 (75.0%)	
	Postgraduate	1 (50.0%)	1 (50.0%)	
Altitude at residence	Sea level	6 (30%)	14 (70%)	0.676
	High altitude	2 (16.7%)	10 (83.3%)	
Reason for ETS	Single indication	5 (26.3%)	14 (73.7%)	1.000
	Multiple indications	3 (23.1%)	10 (76.9%)	
Region of hyperhidrosis	Face	2 (16.7%)	10 (83.3%)	0.676
	Others	6 (30%)	14 (70%)	
Number of ETS levels	Single	2 (18.2%)	9 (81.8%)	0.681
	Multiple	6 (28.6%)	15 (71.4%)	
ETS levels	T2 included	1 (6.7%)	14 (93.3%)	0.041
	T2 excluded	7 (41.2%)	10 (58.8%)	
ETS method	Clipping	3 (21.4%)	11 (78.6%)	1.000
	Cautery	5 (27.8%)	13 (72.2%)	
Regions of compensatory hyperhidrosis	3 or less	4 (26.7%)	11 (73.3%)	1.000
	4 or more	4 (23.5%)	13 (76.5%)	
Time interval between the two surgeries	<48 months	4 (28.6%)	10 (71.4%)	0.703
		4 (22.2%)	14 (77.8%)	
**Median age was taken into consideration.ETS: Endoscopic thoracic sympathectomy, GT: Gebitekin Technique. p-value < 0.05 was considered as statistically significant*				

Table 4. Preoperative and postoperative changes of the WHOQOL-BREF questionnaire subfield/area of health scores.			
Subfield values	Preop value (min/max)	Postop value (min/max)	p value
Physical	12.29 (6.86/17.14)	16.57 (6.29/20.00)	<0.001
Psychological	10.34 (4.00/17.33)	15.33 (4.67/18.67)	<0.001
Social	12.00 (4.00/20.00)	14.67 (4.00/20.00)	<0.001
Environmental	14.50 (9.50/18.00)	16.00 (7.00/19.50)	0.010
Scores were calculated as described in the literature [8] *p-value < 0.05 was considered as statistically significant*			

Table 5. Factors affecting percentage changes of survey subfields.

Variables/Subfields		Physical	Psychological	Social	Environmen al	PhS p-value	PsS p-value	SS p-value	ES p-value
Sex	Female	0.353	0.562	0.077	0.037	0.363	0.229	0.681	0.458
	Male	0.188	0.214	0.144	0.059				
Reason for ETS indication	Single	0.259	0.200	0.144	0.083	0.887	0.545	0.362	0.880
	Multiple	0.210	0.267	0.083	0.037				
ETS level	Single	0.259	0.168	0.101	0.103	0.531	0.938	0.907	0.144
	Multiple	0.188	0.236	0.143	0.033				
ETS method	Clips	0.358 (-0.02-0.81)	0.354	0.129	0.057	0.045	0.613	0.667	0.639
	Cautery/ Dissection	0.170 (-0.14-0.94)	0.214	0.122	0.044				
Time interval between ETS and GT	<48 months	0.171	0.191	0.122	0.068	0.283	0.488	0.925	0.896
	≥48 months	0.317	0.257	0.153	0.049				
Number of compensatory sweating regions	≤3 regions	0.100 (-0.14-0.63)	0.214	0.181	0.029 (-0.26-0.17)	0.018	0.331	0.455	0.027
	≥4 regions	0.280 (-0.05-0.94)	0.278	0.077	0.103 (-0.220.38)				
Complaints besides compensatory sweating	None	0.133 (-0.14-0.81)	0.171	0.074	0.029	0.029	0.110	0.515	0381
	Yes	0.353 (-0.08-0.94)	0.517	0.223	0.087				
Proximal nerve used for GT	T1	0.196	0.241	0.241	0.057	0.512	0.866	0.488	0.837
	T2	0.270	0.225	0.089	0.048				

Abbrev.; ETS: Endoscopic thoracic sympathectomy, GT: Gebitekin Technique, PhS:, PsS: subfield, SS: subfield, ES: PC: Percent change. p-value < 0.05 was considered as statistically significant

Discussion

Primary focal hyperhidrosis is a condition that severely impairs individuals' quality of life (QOL) by affecting their social and professional functioning. The gold standard treatment is surgery, and the most common postoperative complication is compensatory hyperhidrosis (CH) [2,10]. The search for effective treatments for CH is ongoing, with the goal of identifying a permanent approach that may reverse its impact on professional life, QOL, and psychological well-being. Patient complaints have prompted surgeons to develop ETS techniques aimed at minimizing side effects. One such measure was to reduce the levels of ETS performed for PFH, preferably avoiding T2 sympathectomy whenever possible [1,10,11]. A recent meta-analysis by Zhang et al [11] reported that the lowest complication rates were observed in T4 ETS. According to Weksler et al [12], patients with more than one ganglion blockade had a higher risk of developing CH. As a result, Cerfolio et al [1] suggested that operations at the T2 level should be performed only in patients with craniofacial sweating or flushing, and that the associated risks should be explained in detail during preoperative discussions. Unfortunately, severe CH due to ETS still has an incidence of 27.2% [13].

The first nerve reconstruction for the treatment of compensatory hyperhidrosis was performed by Telaranta [14], who used the sural nerve via thoracotomy. After the operation, the reduction in the patient's hot flashes and the decreased severity of CH generated hope for a potential treatment. Another free-flap procedure was performed by Wong et al [15], incorporating the intercostal nerves.

A firefighter with post-sympathectomy hot flashes experienced complete resolution of symptoms after insertion of an intercostal nerve graft between T2 and T4. There are studies in the literature in which intercostal nerves have been used not only at the level of the sympathetic chain but also for brachial plexus injuries [16]. Haam et al [17] presented a series of 19 intercostal nerve implantations in which the distal healthy intercostal nerve, after clearance of fibrosis from the sympathetic chain ends, was transplanted to the area of damage. In

9 of the 19 patients, CH symptoms were markedly reduced. Park et al [4] reported minimal success with the Melbourne Technique, in which a superficial vein graft from the forearm enveloped both ends of the sympathetic chain that had been damaged by ETS. In our clinic, we initially applied a technique similar to that of Haam et al [17]. However, the feedback received from patients was not favorable. This may be related to the fact that the healthy tissue at the proximal damaged end of the sympathetic chain could not be identified macroscopically.

These unsuccessful results prompted us to search for a new method to treat CH. Our hypothesis was that anastomosis of the intercostal nerves above and below the compromised section of the sympathetic chain could create an alternative pathway similar to the Kuntz nerve pathway. Because intercostal nerves have motor, sensory, and autonomic functions, transmission is bidirectional. Additionally, sensory disturbances in the areas of the intercostal nerves used for anastomosis can be compensated by the intercostal nerves above and below the anastomosis. Therefore, intercostal nerve reconstruction does not result in permanent side effects in patients. It is also suggested that the fibrin glue used at the anastomosis line during surgery is important in the initial phase of peripheral nerve regeneration, promoting Schwann cell proliferation [18].

Fifty percent of the patients who underwent GT rated their quality of life as 4 or 5 points after surgery. Furthermore, following the resolution of CH in one of the two patients who had attempted suicide, the patient reported that he no longer required treatment for depression and was able to continue his daily life as normal. In one patient, the heart rate after ETS was less than 50 beats per minute, which increased to 75 during the postoperative follow-up period, resulting in a marked improvement in chronic fatigue.

When patients were asked about the percentage reduction in their CH symptoms, a threshold of ≥10% was accepted as a clinically significant decrease. Thus, 75% of the patients were found to have reduced sweating. Despite this high success rate, the relatively lower satisfaction rate (65.53%) may be attributed to the very high expectations of the patients.

In this treatment method, achieving predictability and consistency in each patient is challenging. Therefore, we compared the preoperative and postoperative responses subjectively. In this context, we applied the 26-item Turkish version of the WHOQOL-BREF questionnaire to assess QOL. We also prepared a short questionnaire to learn about patients' thoughts on ETS, their symptoms, and their history of CH. This newly developed questionnaire aimed to determine the extent to which the operation contributed to patients' quality of life preoperatively and at 6 months postoperatively. This newly developed questionnaire aimed to determine the extent to which the operation contributed to patients' quality of life preoperatively and at 6 months postoperatively.

Intercostal nerve reconstruction reduced sweating in most patients who underwent anastomosis, particularly at the T1 level. The most likely explanation for this may be the excess of T1 efferent fibers. The most important consideration when using the T1 intercostal nerve is to avoid damaging the T1 root that contributes to the brachial plexus. At this level, the intercostal nerve has no sensory branch, and the spinal nerve, once exiting the intervertebral foramen, divides into a thick anterior branch that joins the plexus and a thin intercostal branch. Therefore, dissection of the intercostal nerve should be performed as distally as possible at the lower border of the first rib. None of our patients developed symptoms suggestive of brachial plexus injury. Similarly, none of our patients developed Horner's syndrome.

When examining the health subdomains of the WHOQOL-BREF questionnaire, we found that the psychological health domain had the greatest percentage change, increasing from 10.34 to 15.33 ($p < 0.001$). This finding is not coincidental. When CH symptoms resolved, stress was alleviated, anxiety was reduced, the need for frequent clothing changes decreased, and daily comfort levels increased. Since the data in our study are based on subjective assessments of patient satisfaction, we aimed to determine the threshold of symptom reduction required to improve overall QOL, as compared with patients' reported need for daily clothing changes. As a result of the ROC analysis, a 12.5% decrease in CH symptoms, with 76.92% specificity and 84.21% sensitivity, was identified as the benchmark for reducing the need for daily clothing changes and thereby im-

proving QOL. These data are meaningful in terms of the reliability of patients' subjective evaluations.

Complications related to GT were minor in nature. During the first year of applying the method, a Hemovac drain was placed at the end of the operation. However, due to the risk of hemothorax developing in the early postoperative period, placement of chest drains became the preferred approach. In the four patients in whom hemothorax developed, VATS was the preferred treatment method, since tube thoracostomy could potentially damage the anastomosis. Given the total sample size of 32 patients, the observed complication rates may appear comparatively high. In the period following the description and adoption of the technique, hemothorax occurred during follow-up, likely due to the use of reduced cauterization in the reconstruction area to avoid neural injury. Based on this clinical experience, hemostasis practices were subsequently reinforced, and no further cases of hemothorax were observed in our later series. Revision procedures were performed with VATS, and no active bleeding was detected during these procedures. It was found that tissue adhesives (fibrin glue) applied to the anastomosis line secured the anastomosis to the chest wall. Hyperalgesia that developed in the breasts of two women did not completely resolve. Hypoesthesia or hyperalgesia of the breast is also an important problem affecting female sexual life. For this reason, we perform intercostal nerve reconstruction using the T6 intercostal nerve in women.

In the study published by Rantanen and Telaranta [19] in 2017, 19 patients underwent treatment for CH using free intercostal or sural nerve grafts, and preoperative and postoperative surveys were administered to the patients, similar to our study. A success rate of approximately 75% was reported based on the results of these surveys. However, this questionnaire lacks validity and reliability, as it was developed in a single clinic and the yield of the study was as low as 12.6%. In comparison with other reconstruction methods performed for the treatment of CH, our study demonstrated a 75% success rate with the largest case series and a 65.63% satisfaction rate, based on the subfields of the WHOQOL-BREF questionnaire, making GT the most effective treatment for CH.

Limitations of the study

The present study has several limitations. First, the cohort size was modest, reflecting the rarity of patients undergoing intercostal nerve reconstruction for compensatory hyperhidrosis. Second, a control group was not included, as the procedure is performed selectively in patients with severe CH unresponsive to medical management. Third, the follow-up period of six months provides preliminary but not long-term outcomes. Future prospective studies with larger sample sizes, control groups, and extended follow-up will be necessary to confirm the durability and generalizability of these results.

In conclusion, our survey study demonstrated that patients with CH still represent an unmet clinical need, and the GT offers significant improvements in quality of life, with safe, high, and long-term success rates.

Declaration of conflicting interests

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Ethics approval

The study was approved by the Uludag University Ethics Committee (03/2017-4/41) and the Institutional Review Board.

Authors' contribution

GT: Conceptualization, Methodology, Writing – original draft. HM: Data curation, Investigation. TES: Formal analysis, Visualization. EÖ: Validation, Supervision. EY: Data curation, Software. ASB: Supervision, Validation. CG: Conceptualization, Project administration, Supervision.

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