ORIGINAL ARTICLE
Turk J Surg 2026;42(3):350-357

Turkish version of the Carolinas comfort scale: Validation and long-term clinical outcomes after mesh-based inguinal hernia repair

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ABSTRACT

Objective: Mesh-based inguinal hernia repair has reduced recurrence rates; however, long-term postoperative symptoms remain clinically relevant. The Carolinas comfort scale (CCS) is a disease-specific tool developed to assess these outcomes. This study aimed to validate the Turkish version of the CCS and evaluate long-term quality of life.

Material and Methods: The CCS was translated and culturally adapted using standardized procedures. A retrospective cohort of patients who underwent elective inguinal hernia repair with mesh between 2018 and 2020 was analyzed. Reliability, validity, and factor structure were evaluated using established statistical methods.

Results: A total of 85 patients were included, with a median follow-up of 79 months. The Turkish CCS demonstrated excellent internal consistency (Cronbach's α=0.952), strong convergent validity with VAS (ρ=0.952, $p<0.001$), and significant discriminative validity for chronic pain ($p<0.001$). The recurrence and chronic pain rates were 10.6% and 35.3%, respectively.

Conclusion: The Turkish version of the CCS is a valid and reliable instrument for assessing long-term outcomes after mesh-based inguinal hernia repair and can be used in both clinical practice and research.

Keywords: Carolinas comfort scale, chronic pain, inguinal hernia, quality of life, validation

INTRODUCTION

Inguinal hernia accounts for approximately 75% of all abdominal wall hernias, with a reported lifetime risk of 27% in men and 3% in women (1). With the routine adoption of mesh-based repair techniques, a substantial and dramatic reduction in recurrence rates has been achieved (2,3). However, because mesh materials remain permanently within the body, long-term complications that may adversely affect patient comfort such as foreign body sensation, chronic pain, physical limitation, and psychological impact can occur (4). Consequently, patient-centered assessment of quality of life following mesh-based inguinal hernia repair has gained increasing importance (5).

While generic instruments like the short form-36 (SF-36) and the visual analog scale (VAS) are staples in assessing quality of life and pain following hernia repair, they often struggle to capture the full clinical picture (6). The SF-36, being a broad health measure, frequently lacks the sensitivity required to pinpoint hernia-specific or mesh-related issues. Similarly, the VAS is restricted to pain intensity alone, overlooking critical factors such as foreign body sensation and mobility restrictions that are common after mesh-based procedures (7). To address these gaps, the Carolinas comfort scale (CCS) was developed specifically to evaluate pain, movement limitation, and the sensation of the mesh itself (8). The CCS has been extensively evaluated in the literature, validated across multiple clinical settings, and shown to be a sensitive instrument for assessing postoperative outcomes after mesh repair (8-11).

To date, the CCS has been translated into 25 languages and is currently used in 48 countries worldwide (4). However, a validated Turkish version of the scale is not yet

Cite this article as: Bulut A, Ekdal DC, Acar ÖF, Ekşim B, El Qadiri IM, Semiz M, et al. Turkish version of the Carolinas comfort scale: validation and long-term clinical outcomes after mesh-based inguinal hernia repair. *Turk J Surg.* 2026;42(3):350-357

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Received: 12.05.2026
Accepted: 02.09.2026
Epub: 03.09.2026
Publication Date: 07.09.2026

DOI: 10.47717/turkjsurg.2026.2026-5-24

Available at **www.turkjsurg.com**

available. The present study aims to evaluate long-term quality of life after inguinal hernia repair using the CCS in our cohort and to complete the Turkish cultural adaptation and validation process of the scale.

MATERIAL and METHODS

Translation and Cross-cultural Adaptation

The Turkish adaptation of the CCS was conducted in accordance with internationally accepted guidelines for cross-cultural validation and followed a three-step process. In the first stage, the original English version of the scale was independently translated into Turkish by two translators. One translator was a medical doctor with expertise in surgical terminology, while the other was a professional with advanced proficiency in both English and Turkish but without a medical background. The two forward translations were reviewed and compared by a four-member expert committee consisting of the principal investigator and three additional researchers. Based on linguistic equivalence, semantic integrity, and cultural relevance, a consensus Turkish version was developed. The study was conducted at a medical faculty hospital that provides medical education entirely in English. The principal investigator is a graduate of this institution and currently serves as a faculty member. The research team also included a general surgery specialist and senior medical students from the same faculty. This academic background facilitated careful evaluation of both linguistic accuracy and clinical relevance during the translation process.

The preliminary Turkish version underwent back-translation into English by two independent bilingual individuals. One was an educational counselor who had lived for many years in an English-speaking country (Ireland) and possessed native-level bilingual proficiency, and the other was a professional translator with extensive experience in English-Turkish translation. The back-translated English version was compared with the original scale by the same expert committee. Structural, semantic, and conceptual equivalence between the back-translated and original versions was evaluated by the expert committee in accordance with the original developer's criteria. In the third stage, the finalized Turkish CCS was administered to a pilot group of 10 patients. During the pilot testing, participants were asked to evaluate the clarity of the items, whether any statements led to ambiguity or misinterpretation, and the extent to which the items reflected their personal perceptions. Based on patient feedback, items with limited clarity or potential cultural inadequacy were revised. After these revisions, the final Turkish version of the CCS was formally approved for use in the study (Figure 1). The final Turkish version of the CCS is provided as Supplementary Material.

Study Design and Participants

This study was designed as a retrospective cohort study evaluating long-term outcomes in patients who underwent elective inguinal hernia repair with mesh between 2018 and 2020. In the same cohort, long-term quality of life was assessed cross-sectionally using the Turkish version of the CCS.

Inclusion criteria were age ≥18 years, elective inguinal hernia repair with mesh, and adequate proficiency in the Turkish language. Exclusion criteria included cognitive, auditory,

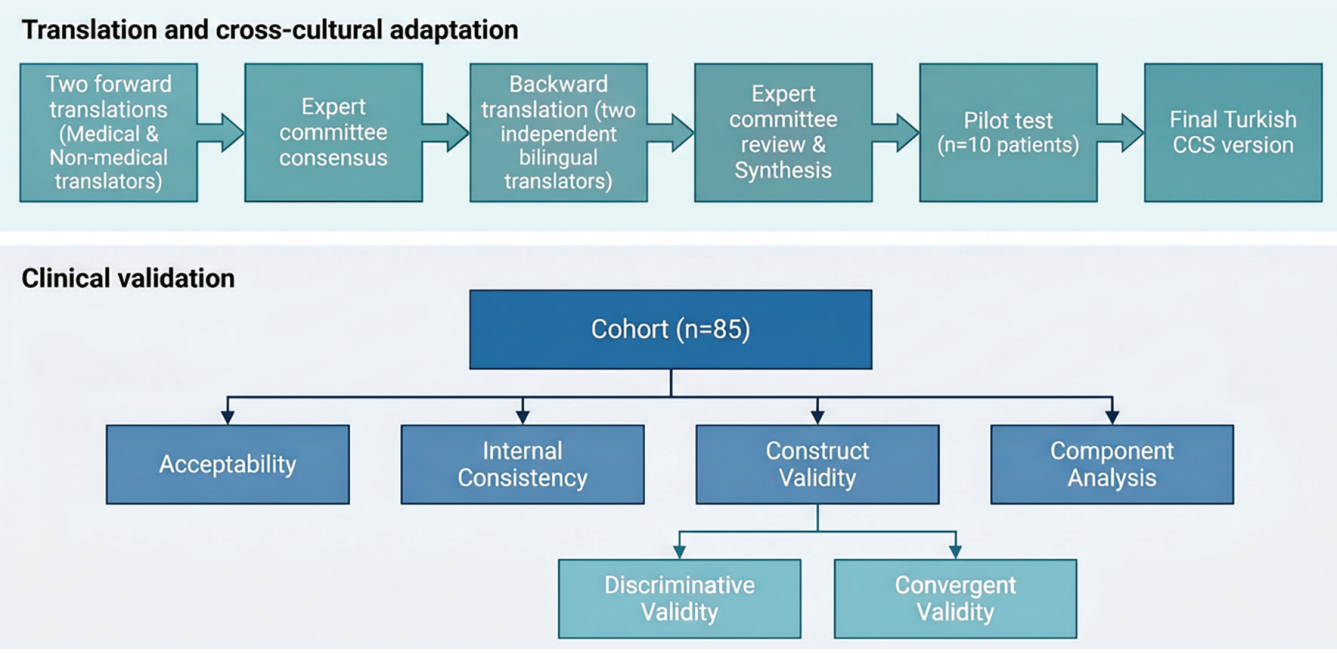

Figure 1. Schematic representation of the study workflow for translation and validation of the Carolinas comfort scale (CCS).

or communication impairments that could interfere with questionnaire completion, surgery for recurrent inguinal hernia, femoral hernia repair using a mesh plug technique, and emergency hernia surgery. The study was conducted in accordance with the principles of the Declaration of Helsinki. Approval was granted by the Marmara University Clinical Research Ethics Committee (reference number: 09.2026.26-0066, date: 16.01.2026). As data collection was performed via telephone interviews, verbal informed consent was obtained from all participants at the beginning of each call after providing a detailed explanation of the study. The obtained consent was documented by the investigator conducting the interview and recorded in the study forms with signature confirmation.

Data Collection and Follow-up

Demographic variables [age, sex, body mass index (BMI)], clinical parameters [American Society of Anesthesiologists (ASA) score, comorbidities and smoking status], and operative characteristics (open or laparoscopic approach, operative time, and length of hospital stay) were obtained from electronic medical records.

Eligible patients were contacted by telephone and were provided with detailed information regarding the study. Verbal informed

consent was obtained from patients who agreed to participate, and the consent form was signed by the interviewing researcher in accordance with institutional regulations. During the interview, patients were asked about the presence of postoperative recurrence, including any swelling at the repair site or history of reoperation for hernia at the same location. All telephone interviews were conducted by four researchers who had received standardized training prior to data collection. The response rate was defined as the proportion of eligible patients who participated in the study out of the total number of patients meeting the inclusion criteria. In accordance with the CCS scoring guidelines, questionnaires with no more than two missing items per subscale were considered acceptable and eligible for analysis. The acceptability of the scale was evaluated based on the proportion of completed questionnaires and the extent of missing data.

The CCS and Pain Assessment

The CCS is a disease-specific patient-reported outcome measure developed to assess quality of life following hernia repair with mesh, particularly focusing on mesh-related symptoms. Permission for the academic use of the CCS and its Turkish linguistic validation was formally obtained from the original developer, B. Todd Heniford, and the Atrium Health Department of Surgery.

The CCS evaluates three domains: pain, sensation of mesh, and movement limitation. Each item is rated on a 6-point Likert scale ranging from 0 to 5, where higher scores indicate greater symptom severity. In addition, a "not applicable" (N/A) option is available for situations not experienced by the patient; such responses were treated as missing data and handled according to the CCS scoring guidelines. The total CCS score is calculated by summing all item responses, with higher scores indicating poorer postoperative comfort and reduced quality of life.

Pain severity was also assessed using the VAS, ranging from 0 (no pain) to 10 (worst imaginable pain). The VAS was used to evaluate convergent validity by examining its correlation with CCS scores.

Outcomes of the Study

The primary outcome of this study was to evaluate the validity and reliability of the Turkish version of the CCS in patients who underwent mesh-based inguinal hernia repair. Secondary outcomes were the presence of chronic pain and hernia recurrence during follow-up.

Statistical Analysis

Statistical analyses were performed using appropriate methods based on the distribution characteristics of the data. The normality of continuous variables was assessed using the Shapiro-Wilk test. Continuous variables were presented as mean ± standard deviation for normally distributed data and as median [interquartile range (IQR)] for non-normally distributed data. Categorical variables were expressed as frequencies and percentages. Internal consistency was assessed using Cronbach's alpha coefficient. Item-total correlations were calculated to evaluate the contribution of each item to the overall scale. Construct validity was evaluated through convergent and discriminative validity analyses. Convergent validity was assessed by examining the correlation between CCS scores and VAS scores using Spearman correlation analysis. Discriminative validity was evaluated by comparing CCS scores between patients with and without chronic pain using the Mann-Whitney U test. Principal component analysis (PCA) with Varimax rotation was performed to examine the factor structure of the CCS. All statistical analyses were performed using Jamovi (version 2.6.44.0). A p-value <0.05 was considered statistically significant.

RESULTS

Patient Characteristics and Clinical Outcomes

A total of 167 patients who underwent elective inguinal hernia repair between January 2018 and December 2020 were initially assessed. After applying the inclusion and exclusion criteria, 85 patients were included in the final analysis (Figure 2). The study population was predominantly male (96.5%). The mean age of the cohort was 54.8±14.9 years. The median BMI was 25.7 (IQR: 4.65), and most patients were classified as ASA II (71.4%). The majority of patients underwent inguinal hernia repair using

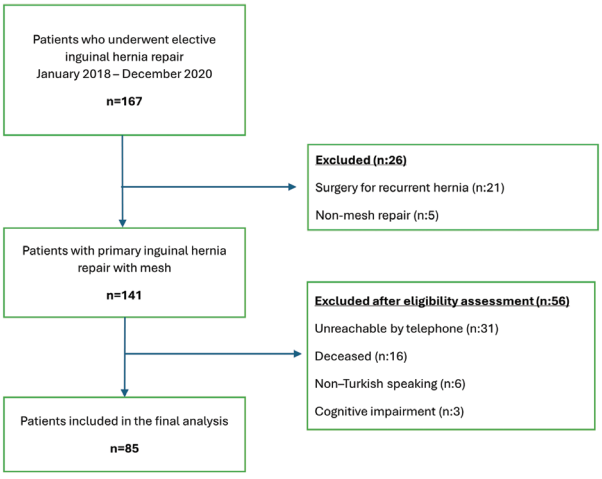

Figure 2. Flowchart of patient inclusion and study design.

the Lichtenstein technique (87.1%), followed by laparoscopic transabdominal preperitoneal repair (11.8%) and intraperitoneal onlay mesh repair (1.2%). The median operative time was 45 minutes (IQR: 29.25). The median long-term follow-up duration was 79 months (IQR: 9). At the time of evaluation, the prevalence of chronic pain was 35.3%, and the recurrence rate was 10.6%. Comprehensive demographic and clinical characteristics are summarized in Table 1.

Acceptability and Internal Consistency

The Turkish version of the CCS was administered via standardized telephone interviews, achieving an acceptability rate of 100%, as all 85 participants fully completed the 23 items with no missing data. The scale demonstrated excellent internal consistency, with an overall Cronbach's alpha coefficient of 0.952. All subscales exceeded the 0.70 reliability threshold: Sensation (α=0.907), pain (α=0.912), and movement limitation (α=0.890). Corrected item-total correlations ranged from 0.351 to 0.862, and the "alpha if item deleted" analysis confirmed the stability of the scale, with coefficients remaining between 0.947 and 0.954 (Table 2).

Construct Validity

Convergent validity was assessed by examining the relationship between CCS scores and VAS scores using Spearman's correlation analysis. A very strong positive correlation was observed between the total CCS score and VAS (ρ=0.952, p<0.001). This association was even stronger for the pain domain (ρ=0.977, p<0.001). In addition, significant moderate correlations were observed between VAS and the sensation (ρ=0.580, p<0.001) and movement limitation domains (ρ=0.599, p<0.001). Discriminative validity was evaluated by comparing CCS scores between clinically distinct groups. Patients with chronic pain

Table 1. Baseline demographic and clinical characteristics of the study population (n=85)

Variable	Value
Age (years), mean ± SD	54.8±14.9
Sex, n (%)	
Male	82 (96.5%)
Female	3 (3.5%)
BMI (kg/m^2), median (IQR)	25.7 (4.65)
ASA score, n (%)	
I	19 (22.6%)
II	60 (71.4%)
III	5 (6.0%)
Hernia side, n (%)	
Right	40 (47.1%)
Left	37 (43.5%)
Bilateral	8 (9.4%)
Surgical technique, n (%)	
Lichtenstein	74 (87.1%)
Laparoscopic (TAPP)	10 (11.8%)
Laparoscopic (IPOM)	1 (1.2%)
Operation time (minutes), median (IQR)	45 (29.25)
Recurrence, n (%)	
No	76 (89.4%)
Yes	9 (10.6%)
Chronic pain, n (%)	
No	55 (64.7%)
Yes	30 (35.3%)
Follow-up duration (months), median (IQR)	79 (9)

SD: Standard deviation, BMI: Body mass index, IQR: Interquartile range, ASA: American Society of Anesthesiologists, TAPP: Transabdominal preperitoneal repair, IPOM: Intraperitoneal onlay mesh.

Table 2. Internal consistency and reliability analysis of the Turkish version of the CCS

Scale/domain	Number of items	Median (range)	Cronbach's α	Corrected item-total correlation (min-max)	α if item deleted (range)
Total CCS	23	0 (0-83)	0.952	0.351-0.862	0.947-0.954
Sensation	8	0 (0-26)	0.907	0.427-0.889	0.877-0.918
Pain	8	0 (0-31)	0.912	0.402-0.941	0.879-0.923
Movement	7	0 (0-26)	0.890	0.434-0.900	0.848-0.900

CCS: Carolinas comfort scale, SD: Standard deviation, IQR: Interquartile range.

reported significantly higher total CCS scores (median: 6.0 vs. 0.0, p<0.001) and pain domain scores (median: 3.0 vs. 0.0, p<0.001) compared to those without chronic pain. Significant differences were also observed in the sensation and movement limitation domains, with higher scores in patients with chronic pain (sensation: p<0.001; movement limitation: p<0.001) (Table 3).

Factor Structure

The PCA was performed to evaluate the underlying factor structure of the Turkish CCS. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.50, indicating borderline adequacy. Bartlett's test of sphericity was significant (p<0.001); however, an exact chi-square statistic could not be estimated because of perfect linear dependence among several items. PCA identified a three-component structure with eigenvalues greater than 1. The three components explained 75.0% of the total variance, with the first component accounting for 52.7%. Following Varimax rotation, several items demonstrated strong loadings (>0.40); however, multiple items exhibited cross-loadings across components. Items related to pain and movement limitation tended to cluster within Component 1, while sensation-related items were distributed across Components 2 and 3. Cross-loadings were particularly observed for items Q4, Q6, and Q16. Several items demonstrated cross-loadings across multiple components. The rotated component matrix is presented in Table 4.

DISCUSSION

The present study aimed to evaluate the validity and reliability of the Turkish version of the CCS, a disease-specific patient-reported outcome measure designed to assess quality of life following hernia repair with mesh (11). With the widespread adoption of mesh-based techniques and the consequent reduction in recurrence rates, postoperative quality of life has emerged as a key outcome in hernia surgery (12). In this context, our findings confirm that the Turkish version of the CCS is a valid and reliable tool for assessing postoperative quality of life.

In terms of internal consistency, the Turkish CCS demonstrated excellent reliability, with a Cronbach's alpha coefficient of 0.952 for the total scale. This finding is highly consistent with the original validation studies, where Cronbach's alpha values exceeded 0.95, confirming the robustness of the scale. Subsequent validation studies in different languages have reported similar findings, including the Lithuanian (α=0.953), Dutch (α=0.948), and Brazilian Portuguese (α=0.94) versions (4,9,13). These results indicate that the CCS maintains consistently high internal reliability across diverse populations. Convergent validity was strongly supported by the very high correlation between CCS and VAS scores (ρ=0.952). As expected, the strongest association was observed for the pain domain (ρ=0.977), reflecting the fact that VAS primarily measures pain intensity. In addition, moderate correlations were observed between VAS and the sensation (ρ=0.580) and movement limitation domains (r=0.599), further supporting the multidimensional nature of the CCS. The ability of the CCS to reflect symptom severity, especially pain, has been emphasized in the original CCS studies, where strong associations were observed between CCS scores and patient-reported symptom burden (11). Comparable relationships have also been demonstrated in studies examining correlations with broader health measures such as SF-36 domains, including physical functioning and bodily pain (4,13), supporting the construct validity of the scale. Discriminative validity was also clearly demonstrated in our cohort. Patients with chronic pain exhibited significantly higher CCS scores compared to those without chronic pain, indicating that the scale effectively distinguishes between clinically relevant groups. This finding is consistent with earlier studies showing that CCS scores correlate with patient satisfaction, symptom severity, and functional outcomes (8-10,13). These findings reinforce the clinical

Table 3. Assessment of construct validity of the Turkish version of the CCS

Analysis type	Variables	Statistical test	Coefficient/statistic	p-value
Convergent validity	CCS total vs. VAS	Spearman	ρ=0.952	<0.001
Convergent validity	Pain domain vs. VAS	Spearman	ρ=0.977	<0.001
Convergent validity	Sensation domain vs. VAS	Spearman	ρ=0.580	<0.001
Convergent validity	Movement domain vs. VAS	Spearman	ρ=0.599	<0.001
Discriminative validity	CCS total (with vs. without chronic pain)	Mann-Whitney	U=12	<0.001
Discriminative validity	Pain domain (with vs. without chronic pain)	Mann-Whitney	U=0.0	<0.001
Discriminative validity	Sensation domain (with vs. without chronic pain)	Mann-Whitney	U=455.5	<0.001
Discriminative validity	Movement domain (with vs. without chronic pain)	Mann-Whitney	U=467.5	<0.001

CCS: Carolinas comfort scale, VAS: Visual analog scale.

Table 4. Rotated component loadings of the CCS items based on principal component analysis (varimax rotation)			
Item	**Component 1**	**Component 2**	**Component 3**
Q1 (lying down-sensation)	—	0.764	—
Q2 (lying down-pain)	0.777	—	—
Q3 (bending over-sensation)	—	0.810	—
Q4 (bending over-pain)	0.560	0.532	—
Q5 (bending over-movement)	0.658	—	—
Q6 (sitting up-sensation)	0.590	0.567	—
Q7 (sitting up-pain)	0.650	—	—
Q8 (sitting up-movement)	0.763	—	—
Q9 (ADL-sensation)	—	—	0.931
Q10 (ADL-pain)	0.732	—	—
Q11 (ADL-movement)	—	—	0.931
Q12 (coughing/breathing-sensation)	—	—	0.712
Q13 (coughing/breathing-pain)	—	—	0.534
Q14 (coughing/breathing-movement)	—	—	0.931
Q15 (walking-sensation)	—	0.845	—
Q16 (walking-pain)	0.524	0.453	0.431
Q17 (walking-movement)	0.828	—	—
Q18 (stairs-sensation)	—	0.871	—
Q19 (stairs-pain)	0.781	—	—
Q20 (stairs-movement)	0.724	—	—
Q21 (exercise-sensation)	—	0.844	—
Q22 (exercise-pain)	0.694	—	—
Q23 (exercise-movement)	0.730	—	—

ADL: Activities of daily living, CCS: Carolinas comfort scale. Principal component analysis with Varimax rotation was used. Loading weights below 0.40 are omitted (—) for clarity. Loadings below 0.30 were suppressed.

applicability of the CCS in identifying patients with impaired postoperative quality of life.

The factor structure of the Turkish CCS was evaluated using principal component analysis. A three-component structure was identified, consistent with the conceptual domains of the original scale. However, several items demonstrated cross-loadings across components, and a clear separation between components was not observed, particularly for the sensation domain. In the original CCS reappraisal study, a dominant component explaining a large proportion of variance was reported, suggesting a more compact structure (8). Similarly, the Lithuanian validation study identified three components, with the first accounting for 56% of the variance (4). In our analysis, the first three components explained 75.0% of the total variance, with the first component alone accounting for 52.7%. The KMO value (0.50) was at the threshold of adequacy, likely reflecting the sample size relative to the number of items, while the significant Bartlett's test confirmed the suitability of the data for factor analysis. The presence of cross-loadings for certain items (Q4, Q6 and Q16) may reflect the overlapping nature of postoperative symptoms. In long-term follow-up settings, such as in our cohort with a median follow-up of 79 months, pain and movement limitation often coexist during complex physical activities, leading to shared variance between domains. This is consistent with previous clinical observations that mesh-related symptoms frequently overlap in real-world settings (14). Despite these overlaps, the extraction of three components and the overall distribution of items remained broadly aligned with the conceptual framework of the CCS, suggesting that the Turkish version generally reflects the intended domain structure.

In our cohort, with a relatively long median follow-up of 79 months, the recurrence rate was 10.6%. The majority of patients (87%) underwent open Lichtenstein repair. In a large study by Murphy et al. (15), which analyzed three major United States databases (Premier, NSQIP, and Mayo Clinic), operations performed for recurrent groin hernia were found to account for at least 10% of all groin hernia repairs. In that study, earlier small-scale reports suggesting recurrence rates of 1-5% were considered overly optimistic. Although the analysis was not limited to a single operative technique, it included both open

and minimally invasive repairs, with open repairs comprising the majority of cases, similar to our cohort. The same study also noted that recurrence rates reported in United States studies ranged from 0% to 15%, while national hernia registry data from Denmark and Sweden showed that approximately 13-15% of hernia operations were performed for recurrence. Moreover, another review has reported studies describing recurrence rates of up to 16% (6). In this context, the recurrence rate observed in our study appears acceptable and consistent with real-world long-term data.

Chronic pain was observed in 35% of patients in our study. Notably, this rate also included patients with minimal pain (VAS score of 1), which may have contributed to the relatively higher prevalence. Previous studies have reported chronic pain rates ranging from approximately 21% to 36.7% following mesh-based inguinal hernia repair, particularly after open techniques (14). In the randomized study by Eklund et al. (16), the prevalence of chronic pain decreased over time, from 24.8% at 2 years to 18.8% at 5 years of follow-up. The same study also noted that some reports in the literature have described chronic pain rates as high as 75% after open hernia repair. Considering that even patients with very mild symptoms were classified as having chronic pain in our analysis, our results can be regarded as acceptable and in line with the existing literature.

Study Limitations

This study has some limitations must be acknowledged. The sample size of 85 patients, while sufficient for preliminary validation, was relatively small for a comprehensive factor analysis. This is reflected in the KMO value of 0.50, which sits at the threshold of adequacy for sampling. Consequently, the factor structure observed in our PCA may be sensitive to sample size, and larger multicenter studies are needed to confirm these findings. Second, test-retest reliability was not performed in this study, which limits our ability to assess the stability of the Turkish CCS over time. Third, the data were collected via standardized telephone interviews rather than the traditional self-administration method. While this approach ensured a 100% completion rate, it may have introduced interviewer bias or social desirability bias, where patients might feel inclined to report better outcomes than they truly experience. Finally, the single-center and retrospective nature of the study may limit the generalizability of the results to the broader Turkish population or different clinical settings. However the study has several notable strengths. First, the linguistic and cultural adaptation process was conducted with high methodological rigor. Formal permission was obtained from the original developer of the scale, ensuring that the Turkish version remained faithful to the intended conceptual framework. The translation process benefited from a multidisciplinary approach, involving both surgical experts and professional linguists. Furthermore, the study was conducted within an academic environment where medical education is entirely in English, which facilitated a more precise evaluation of linguistic equivalence and clinical relevance. A major strength of our study is the exceptionally long follow-up duration, with a median of 79 months. This period is significantly longer than many existing validation studies and provides valuable insights into real-world long-term outcomes following mesh-based hernia repair. Additionally, we proactively addressed the common challenge of loss to follow-up in long-term cohorts. By utilizing public directory services and institutional identity verification systems to locate patients whose contact information had changed, we were able to minimize attrition and maintain a representative sample of our original cohort.

CONCLUSION

The Turkish version of the CCS is a valid and reliable instrument for assessing quality of life following mesh-based inguinal hernia repair. The long-term follow-up further supports the applicability of the CCS in evaluating persistent postoperative symptoms in real-world clinical settings. These findings suggest that the Turkish CCS can be effectively used in both clinical practice and future research to assess patient-reported outcomes after inguinal hernia repair.

Ethics

Ethics Committee Approval: The study was conducted in accordance with the principles of the Declaration of Helsinki. Approval was granted by the Marmara University Clinical Research Ethics Committee (reference number: 09.2026.26-0066, date: 16.01.2026).

Informed Consent: Verbal informed consent was obtained from all participants, as approved by the ethics committee due to the retrospective design and telephone-based follow-up. Consent was documented by the investigators during telephone interviews.

Acknowledgments

Artificial intelligence-based tools were used solely to assist with language editing and translation. No AI tools were used for study design, data collection, data analysis, interpretation of results, or manuscript authorship. All scientific content, analyses, and conclusions are the sole responsibility of the authors.

The authors would like to express their sincere gratitude to B. Todd Heniford, MD, FACS, and Atrium Health for granting permission to use the original Carolinas comfort scale. We are deeply grateful to Damla Soydan Çabuk for her valuable contribution to the forward translation process. We also extend our sincere appreciation to Aslı Sema Öztürk and Zeynep İlbasmış for their careful and dedicated work in the backward translation.

Footnotes

Author Contributions

Surgical and Medical Practices - A.B., D.C.E., Ö.G.; Concept - A.B., Ö.F.A., B.E., Ö.G.; Design - A.B., D.C.E., I.M.E.Q., M.S.; Data Collection or Processing - A.B., Ö.F.A., B.E., M.S.; Analysis or Interpretation - A.B., D.C.E., Ö.F.A., I.M.E.Q., N.M., Ö.G.; Literature Search - A.B., B.E., I.M.E.Q., N.M., M.S.; Writing - A.B., D.C.E., Ö.F.A., B.E., I.M.E.Q., M.S., N.M., Ö.G.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

Supplementary Material Link: https://d2v96fxpocvxx.cloudfront.net/b37683d5-c547-4565-8c20-fa38c0b1ec76/content-images/1b3760ae-46c9-4817-95f1-76a89eff0e0f.pdf

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