ORIGINAL RESEARCH

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Analysis of Patients Who Underwent Surgery for Gastric Gastrointestinal Stromal Tumors

Mide Gastrointestinal Stromal Tümör Nedeniyle Opere Edilen Hastaların Analizi

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Abstract

Objective: To evaluate the clinicopathological characteristics, surgical management, and medium-term outcomes of patients who underwent surgery for gastric gastrointestinal stromal tumors (GISTs).

Method: This single-center retrospective cohort study included 39 consecutive patients who underwent surgery for histopathologically confirmed gastric GIST between January 2016 and June 2026. Clinical, surgical, pathological, and follow-up data were reviewed. Overall survival was estimated using the Kaplan-Meier method, and median follow-up was calculated using the reverse Kaplan-Meier method.

Results: The mean age was 60.4±12.6 years. Laparoscopic surgery was performed in 30 patients (76.9%), and wedge resection in 34 (87.2%). The median tumor diameter was 4.5 cm. Among 34 patients with an available risk classification, 28 (82.4%) had very low- or low-risk tumors, four had intermediate-risk tumors, and two had high-risk tumors. R0 resection was achieved in all 38 patients with evaluable margin status. Six patients (15.4%) experienced Clavien-Dindo grade II complications. No documented recurrence was identified among the 38 patients with evaluable recurrence status. Median follow-up calculated using the reverse Kaplan-Meier method was 42 months. Overall survival was 97.4% at 24 and 48 months and 86.6% at 60 months; however, only nine patients remained at risk at 60 months.

Conclusion: Organ-preserving wedge resection and a laparoscopic approach were frequently used in selected patients with localized gastric GIST, and R0 resection was achieved in all patients with

Öz

Amaç: Cerrahi uygulanan gastrik gastrointestinal stromal tümörlerin (GIST) klinikopatolojik özelliklerini, cerrahi yönetimini ve orta dönem sonuçlarını değerlendirmektir.

Yöntem: Bu tek merkezli retrospektif kohort çalışmasına, Ocak 2016-Haziran 2026 tarihleri arasında histopatolojik olarak doğrulanmış gastrik GIST nedeniyle cerrahi uygulanan 39 ardışık hasta dahil edildi. Klinik, cerrahi, patolojik ve takip verileri incelendi. Genel sağkalım Kaplan-Meier, medyan takip süresi ise ters Kaplan-Meier yöntemiyle hesaplandı.

Bulgular: Hastaların ortalama yaşı 60,4±12,6 yıldı. Otuz hastaya (%76,9) laparoskopik cerrahi, 34 hastaya (%87,2) wedge rezeksiyon uygulandı. Medyan tümör çapı 4,5 cm idi. Risk sınıfı bilinen 34 hastanın 28'i (%82,4) çok düşük veya düşük risk grubundaydı; dört hasta orta, iki hasta yüksek riskliydi. Cerrahi sınır durumu değerlendirilebilen 38 hastanın tamamında R0 rezeksiyon sağlandı. Altı hastada (%15,4) Clavien-Dindo derece II komplikasyon gelişti. Nüks durumu değerlendirilebilen 38 hastanın hiçbirinde belgelenmiş nüks saptanmadı. Ters Kaplan-Meier yöntemine göre medyan takip süresi 42 aydı. Genel sağkalım 24. ve 48. aylarda %97,4, 60. ayda %86,6 olarak hesaplandı; ancak 60. ayda risk altında yalnızca dokuz hasta bulunmaktaydı.

Sonuç: Seçilmiş lokalize gastrik GIST hastalarında organ koruyucu wedge rezeksiyon ve laparoskopik yaklaşım sık uygulanmış, değerlendirilebilir hastaların tamamında R0 rezeksiyon sağlanmıştır. Orta dönem sonuçlar olumlu olmakla birlikte düşük

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Abstract

evaluable margin status. Although medium-term outcomes were favorable, the predominance of low-risk tumors, limited sample size, and declining number of patients at risk during later follow-up preclude definitive conclusions regarding long-term oncological outcomes.

Keywords: Gastric gastrointestinal stromal tumor, minimally invasive surgery, wedge resection

Öz

riskli tümörlerin ağırlığı, sınırlı örneklem büyüklüğü ve ileri takip dönemlerindeki azalan hasta sayısı uzun dönem onkolojik çıkarımları sınırlandırmaktadır.

Anahtar kelimeler: Gastrik gastrointestinal stromal tümör, minimal invaziv cerrahi, wedge rezeksiyon

Introduction

Gastrointestinal stromal tumors (GISTs) are the most common mesenchymal neoplasms of the gastrointestinal tract, with the stomach representing their predominant site of origin. Their biological behavior is heterogeneous: Small tumors with low mitotic activity may remain clinically silent for prolonged periods, whereas more aggressive lesions may exhibit local invasion, peritoneal dissemination, or distant metastasis. The identification of oncogenic driver alterations, particularly those involving KIT and platelet-derived growth factor receptor alpha (PDGFRA), has substantially transformed the diagnostic classification and systemic treatment of GISTs (1-6).

The clinical presentation of gastric GISTs varies according to tumor size, anatomical location, growth pattern, and mucosal ulceration. Small lesions may be detected incidentally, whereas larger tumors may present with abdominal pain, gastrointestinal bleeding, early satiety, anemia, or an abdominal mass. Contrast-enhanced computed tomography is the principal modality for assessing tumor size, adjacent structures, and metastatic disease. Endoscopic ultrasonography and tissue sampling are used selectively when the diagnosis is uncertain, neoadjuvant treatment is considered, or pathological confirmation may alter management. Diagnosis is based on morphology and immunohistochemical markers, particularly CD117 and DOG1, while molecular testing refines classification and informs prognostic, predictive, and treatment decisions (1-4,6).

Surgery is the mainstay of treatment for localized and resectable gastric GISTs. The objective is macroscopically complete resection with a microscopically negative margin while preserving the tumor pseudocapsule and avoiding rupture. Routine lymphadenectomy is not recommended because lymph node metastasis is uncommon. The stomach often permits organ-preserving wedge resection instead of more extensive resection. A laparoscopic approach may be considered for appropriately sized and located tumors without adjacent organ invasion and has been associated with shorter hospital stay and acceptable perioperative outcomes in selected patients. The approach should nevertheless be individualized according to tumor anatomy and technical complexity (1-4,7,8).

Tumor size, mitotic activity, and tumor rupture are among the principal determinants of recurrence risk in gastric GISTs (1-6). In retrospective series with heterogeneous follow-up durations, oncological outcomes should be assessed using time-to-event methods that appropriately account for censored observations. Although single-center series can reflect routine surgical practice and real-world outcomes, missing data and the duration of follow-up must be reported transparently. The primary aim of this study was to evaluate the clinical, surgical, histopathological, and immunohistochemical characteristics of patients who underwent surgery for histopathologically confirmed gastric GIST. The secondary aim was to assess postoperative follow-up findings, documented recurrences, and medium-term survival outcomes using appropriate time-to-event methods.

Materials and Methods

Study Design and Patient Selection

This single-center, retrospective observational cohort study was conducted at the department of general surgery of University of Health Sciences Turkey, İstanbul Bakırköy Dr. Sadi Konuk Training and Research Hospital between January 2016 and June 2026. The study was reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) recommendations (9).

Adult patients who underwent surgical resection for a presumed gastric subepithelial tumor during the study period were assessed for eligibility. Consecutive patients with a definitive histopathological diagnosis of gastric GIST and available essential clinical, operative, and histopathological

data were included. Patients with insufficient essential records and those whose final histopathological diagnosis was other than gastric GIST were excluded.

A total of 64 potentially eligible patients were screened during the study period. Four patients with incomplete essential records and 21 patients with a final histopathological diagnosis other than gastric GIST were excluded. The final study cohort comprised 39 patients with histopathologically confirmed gastric GIST. The patient selection process is presented in Figure 1.

The study was approved by the Local Clinical Research Ethics Committee of University of Health Sciences Turkey, İstanbul Bakırköy Dr. Sadi Konuk Training and Research Hospital before its initiation (approval date: June 19, 2026; decision no: 2026-14-26). Written informed consent for the use of clinical data for research purposes was obtained from all patients before their inclusion in the study. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Data Sources and Clinical Variables

Data were retrospectively obtained by reviewing the hospital electronic medical records, operative notes, imaging reports, final pathology reports, and outpatient follow-up records. The recorded variables included age, sex, body mass index (BMI), American Society of Anesthesiologists (ASA) physical status classification, Charlson comorbidity index (CCI), history of previous abdominal surgery, smoking and alcohol consumption, and presenting symptoms.

The preoperative assessment included whether upper gastrointestinal endoscopy, endoscopic ultrasonography, abdominal ultrasonography, contrast-enhanced computed tomography, magnetic resonance imaging, and positron emission tomography had been performed, together with the reported findings of these examinations. Preoperative tissue sampling was performed under endoscopic ultrasonographic guidance using fine-needle aspiration. The histopathological results were categorized as compatible with GIST or non-diagnostic. Core tissue acquisition was not performed. The presence of distant metastasis at diagnosis was determined from imaging findings and clinical records.

Surgical Assessment

The surgical variables comprised the anatomical location of the tumor within the stomach, its relationship with the gastric curvature, the surgical approach, the type of gastric resection, and operative duration. Tumor location was categorized as the antrum, body, or fundus. Its relationship with the gastric curvature was classified as greater

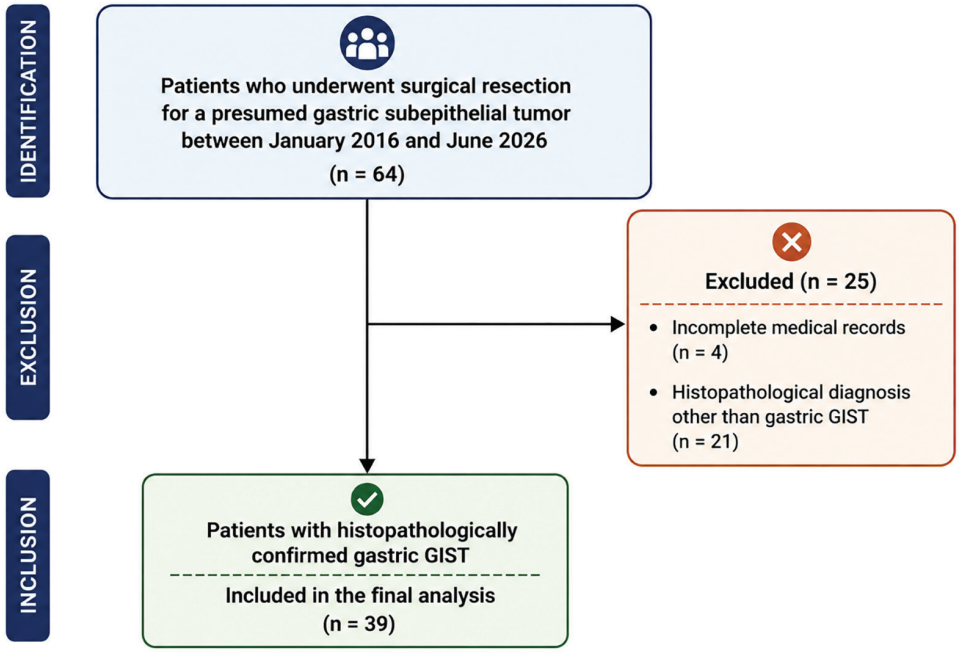

Figure 1. Flow diagram of patient selection
GIST: Gastrointestinal stromal tumor

curvature, lesser curvature, or not reported. The surgical approach was recorded as laparoscopic or open, whereas the type of resection was categorized as wedge resection, subtotal gastrectomy, or total gastrectomy.

The surgical approach was not selected according to a standardized protocol predefined for the purposes of this study. The treatment team determined the operative approach based on tumor size and anatomical location, its relationship with adjacent structures, technical resectability, and the need for concomitant surgical procedures.

Postoperative Assessment

Postoperative length of hospital stay was calculated from the date of surgery to the date of discharge. Postoperative complications were graded according to the Clavien-Dindo classification. Ninety-day mortality was defined as death from any cause within the first 90 days after surgery. Adjuvant imatinib use and all-cause mortality during follow-up were also recorded.

Histopathological Assessment

Histopathological data were obtained from the final pathology reports. The assessed variables included histological cell type, cellularity, cellular atypia, maximum tumor diameter, mitotic count per 5 mm², tumor necrosis, lymphovascular invasion, perineural invasion, resection margin status, integrity of the resection specimen, and the risk category documented in the pathology report. Cellularity and cellular atypia were recorded as reported in the original pathology reports, and no retrospective classification was performed for missing data.

Risk categories were recorded as very low, low, intermediate, or high according to the modified National Institutes of Health classification documented in the pathology reports (10). Patients without a reported risk category were not retrospectively assigned to a new risk group.

A microscopically tumor-free resection margin was considered an R0 resection. Patients with unavailable resection margin information were not classified as having an R1 resection. Resection margin status was presented in the tables as negative or not reported, and the R0 resection rate among evaluable patients was calculated separately.

Cases described as having "incomplete specimen integrity" in the pathology report were identified separately. For the retrospective assessment of tumor rupture, tumor fracture or spillage into the peritoneal cavity, blood-stained ascites, gastrointestinal perforation at the tumor site, microscopic invasion of an adjacent organ, intralesional dissection or piecemeal resection, and incisional biopsy were considered criteria for tumor rupture (11). Tumor rupture was considered confirmed only when at least one predefined rupture criterion was documented in the operative or detailed pathology records. Therefore, incomplete specimen integrity alone was not regarded as definitive tumor rupture.

Immunohistochemical and Molecular Assessment

The recorded immunohistochemical findings included staining results for CD117, DOG1, CD34, smooth muscle actin (SMA), desmin, S100, and CD31. The result for each marker was classified as positive, negative, or not reported. The Ki-67 proliferation index was assessed as a continuous percentage and was also categorized as <10% or ≥10%. Patients without an available Ki-67 result were excluded from these assessments.

Molecular mutation analysis, including testing for KIT and PDGFRA mutations, had not been performed in any patient. Consequently, the relationships between mutation status and risk classification, adjuvant imatinib use, or oncological outcomes could not be evaluated.

Follow-up and Oncological Outcomes

Follow-up data were obtained from outpatient examinations, imaging reports, and hospital electronic records. Follow-up data were censored in June 2026. Follow-up duration was calculated from the date of surgery to the date of the last clinical contact or death.

Overall survival was defined as the interval from surgery to death from any cause. Patients who were alive at the end of follow-up were censored at the date of their last clinical contact. Recurrence was defined as local, peritoneal, or distant GIST recurrence documented by imaging, histopathological examination, or clinical records during follow-up. Patients with unavailable recurrence information were not considered recurrence-free and were excluded from the denominator used to calculate the recurrence rate.

Because no documented recurrence occurred during follow-up, separate Kaplan-Meier estimates of disease-free or recurrence-free survival were not generated. Recurrence outcomes were presented descriptively as numbers and percentages. Time-to-event analysis was performed only for overall survival.

Statistical Analysis

Continuous variables were summarized using the mean ± standard deviation, median, and minimum-maximum

values. Categorical variables were presented as numbers and percentages. The proportions of patients who underwent each preoperative examination were calculated using the entire study cohort, whereas percentages relating to examination findings were calculated using the number of patients who underwent the corresponding examination. Unless otherwise specified, percentages in the remaining tables were calculated using the entire study cohort, and unreported data were presented as a separate category. For proportions calculated among evaluable patients, the denominator was explicitly reported. No imputation was performed for missing data.

The study sample comprised all consecutive patients who met the eligibility criteria during the predefined study period, and no a priori sample size calculation was performed. Given the descriptive study design, limited sample size, non-randomized selection of the surgical approach, and unequal group sizes, no hypothesis-testing comparison was performed between the laparoscopic and open surgery groups. No multivariable model of prognostic factors was constructed.

Overall survival was estimated using the Kaplan-Meier product-limit method. The 95% confidence intervals for survival estimates were calculated using Greenwood's variance and a log-log transformation. The numbers of patients at risk at 0, 12, 24, 36, 48, 60, 84, and 120 months were displayed below the survival curve.

Median follow-up duration was estimated using the reverse Kaplan-Meier method, in which the death and censoring indicators were reversed (12). Observed follow-up duration was also summarized using the mean ± standard deviation, median, and minimum-maximum values. Statistical analyses were performed in Python version 3.12 using reproducible analysis code. Data management and descriptive analyses were conducted using pandas version 2.2.3 and SciPy version 1.17.0.

Results

Patient Selection and Baseline Clinical Characteristics

Of 64 patients assessed after surgical resection for a presumed gastric subepithelial tumor, four with incomplete essential records and 21 with a final diagnosis other than gastric GIST were excluded. The final cohort comprised 39 patients with histopathologically confirmed gastric GIST (Figure 1).

The mean age of the patients was 60.4±12.6 years, and the median age was 63 years (range, 22-78 years). The cohort included 22 women (56.4%) and 17 men (43.6%). Among the 37 patients with available BMI data, the mean BMI was 28.7±5.8 kg/m^2 and the median was 27.8 kg/m^2 (range, 18.5-46.7 kg/m^2). BMI data were unavailable for two patients. Seventeen patients (43.6%) were classified as ASA physical status II and 22 (56.4%) as ASA physical status III. The mean CCI was 2.7±1.5, with a median of 3 (range, 0-6). Nineteen patients (48.7%) had a history of previous abdominal surgery.

Abdominal pain was the most common presenting symptom (n=17, 43.6%). Gastrointestinal bleeding was recorded in seven patients (17.9%), dyspepsia in six (15.4%), and fatigue in two (5.1%). Seven patients (17.9%) were asymptomatic and were diagnosed incidentally during examinations performed for other reasons. Ten patients (25.6%) were smokers, and four (10.3%) reported alcohol consumption. The baseline clinical characteristics of the patients are presented in Table 1.

Preoperative Diagnostic Assessment

Upper gastrointestinal endoscopy and contrast-enhanced computed tomography were performed in all patients. Endoscopy demonstrated a subepithelial lesion considered compatible with GIST in 32 patients (82.1%), extrinsic compression in three (7.7%), and a mass that was not initially considered to represent a GIST in one (2.6%). No distinct endoscopic lesion was identified in three patients (7.7%).

Contrast-enhanced computed tomography demonstrated a mass compatible with GIST in 29 patients (74.4%), gastric wall thickening in four (10.3%), and a lesion initially considered to be of extragastric origin in two (5.1%). No finding suggestive of GIST was identified on computed tomography in four patients (10.3%).

Endoscopic ultrasonography was performed in 15 patients (38.5%), magnetic resonance imaging in 14 (35.9%), positron emission tomography in seven (17.9%), and abdominal ultrasonography in three (7.7%). Among the patients who underwent endoscopic ultrasonography, five had a submucosal lesion and five had a lesion originating from the muscularis propria; the layer of origin was not specified in the remaining five patients. Preoperative fine-needle aspiration biopsy (FNAB) was performed in 13 patients, yielding pathological findings compatible with GIST in 12 (92.3%); the sample obtained from one patient was non-diagnostic. No patient had distant metastasis at the time of diagnosis. The preoperative diagnostic findings are presented in Table 2.

Table 1. Baseline demographic and clinical characteristics of the study population (n=39)

		Min-max			Median	Mean ± SD/n-%		
Age (years)		22.0	-	78.0	63.0	60.4	±	12.6
Sex	Female					22		56.4
	Male					17		43.6
BMI (kg/m^2)		18.5	-	46.7	27.8	28.7	±	5.8
ASA score	II					17		43.6
	III					22		56.4
CCI		0.0	-	6.0	3.0	2.7	±	1.5
Previous abdominal surgery	Yes					19		48.7
	No					20		51.3
Presenting symptom	Abdominal pain					17		43.6
	Gastrointestinal bleeding					7		17.9
	Asymptomatic					7		17.9
	Dyspepsia					6		15.4
	Fatigue					2		5.1
Smoking status	Yes					10		25.6
	No					29		74.4
Alcohol consumption	Yes					4		10.3
	No					35		89.7

BMI: Body mass index, ASA: American Society of Anesthesiologists, CCI: Charlson comorbidity index, SD: Standard deviation, BMI data were available for 37 patients

Surgical Findings

The tumor was located in the fundus in 16 patients (41.0%), the body in 15 (38.5%), and the antrum in eight (20.5%). The relationship with the gastric curvature was reported in 33 patients: 20 tumors were associated with the lesser curvature and 13 with the greater curvature. This information was not reported in six patients.

A laparoscopic approach was used in 30 patients (76.9%), whereas nine patients (23.1%) underwent open surgery. Wedge resection was the most frequently performed procedure, accounting for 34 operations (87.2%). Subtotal gastrectomy was performed in three patients (7.7%) and total gastrectomy in two (5.1%).

The mean operative duration was 114.5 ± 85.1 minutes, and the median was 94 minutes (range, 45-515 minutes). The 515-minute operation included a concomitant oncological debulking procedure for ovarian cancer in addition to gastric resection. Surgical characteristics are presented in Table 3.

Histopathological Findings

The histological cell type was spindle-cell in 24 patients (61.5%), mixed in eight (20.5%), and epithelioid in five (12.8%). Cell type was not reported in two patients. Two separate GIST foci were identified in the gastric resection specimen of one patient.

The mean tumor diameter was 6.3±5.5 cm, and the median was 4.5 cm (range, 0.8-32 cm). The mean mitotic count was 3.0±2.8 per 5 mm^2, with a median of 2 per 5 mm^2 (range, 1-14 per 5 mm^2). The mitotic count was ≤5 per 5 mm^2 in 36 patients (92.3%) and >5 per 5 mm^2 in three patients (7.7%).

Tumor necrosis was present in 14 patients (35.9%) and absent in 23 (59.0%); necrosis status was not reported in two patients. According to the documented risk classification, 17 patients (43.6%) were categorized as very low risk, 11 (28.2%) as low risk, four (10.3%) as intermediate risk, and two (5.1%) as high risk. Risk category was not reported in five patients (12.8%).

R0 resection was achieved in all 38 patients with evaluable margin status; margin status was unavailable for one patient, who was not classified as having an R1 resection.

Specimen integrity was complete in 24 patients and incomplete in four; it was not reported in 11. Among 28 evaluable patients, the corresponding proportions were 85.7% and 14.3%. Lymphovascular and perineural invasion were evaluated in only five and three patients, respectively, and were absent in all evaluable cases. These variables were not interpreted further because of extensive missing data (Table 4).

Table 2. Preoperative evaluation of the patients (n=39)

		n	%
Upper gastrointestinal endoscopy		39	100.0%
Endoscopic findings	Findings compatible with GIST	32	82.1%
	Mass lesion (GIST not suspected)	1	2.6%
	Extrinsic compression	3	7.7%
	No lesion detected	3	7.7%
Endoscopic ultrasonography		15	38.5%
EUS findings	Submucosal lesion	5	33.3%
	Muscularis propria origin	5	33.3%
	Not specified	5	33.3%
Abdominal ultrasonography		3	7.7%
Ultrasonography findings	Mass detected	2	66.7%
	No mass detected	1	33.3%
Contrast-enhanced computed tomography		39	100.0%
Computed tomography findings	Findings compatible with GIST	29	74.4%
	Gastric wall thickening	4	10.3%
	Normal findings	4	10.3%
	Extragastric lesion	2	5.1%
Magnetic resonance imaging		14	35.9%
MRI findings	Findings compatible with GIST	10	71.4%
	Findings not suggestive of GIST	3	21.4%
	Extragastric lesion	1	7.1%
Positron emission tomography		7	17.9%
PET findings	Findings compatible with GIST	7	100.0%
Fine-needle aspiration biopsy		13	33.3%
Biopsy findings	Histopathological findings compatible with GIST	12	92.3%
	Non-diagnostic sample	1	7.7%
Distant metastasis		0	0.0%

GIST: Gastrointestinal stromal tumor, EUS: Endoscopic ultrasonography, MRI: Magnetic resonance imaging, PET: Positron emission tomography. Percentages for performed examinations were calculated using the total cohort (n=39), whereas percentages for examination findings were calculated using the number of patients who underwent the corresponding examination

Table 3. Operative characteristics of the patients (n=39)

		Min-max			Median	Mean ± SD/n-%		
Tumor location	Antrum					8		20.5%
	Body					15		38.5%
	Fundus					16		41.0%
Relation to gastric curvature	Greater curvature					13		33.3%
	Lesser curvature					20		51.3%
	Not reported					6		15.4%
Surgical approach	Laparoscopic					30		76.9%
	Open					9		23.1%
Type of gastric resection	Wedge resection					34		87.2%
	Subtotal gastrectomy					3		7.7%
	Total gastrectomy					2		5.1%
Operative time (minutes)		45.0	-	515.0	94.0	114.5	±	85.1

SD: Standard deviation

Table 4. Histopathological characteristics of the patients (n=39)								
		Min-max			Median	Mean ± SD/n-%		
Cell type	Spindle					24		61.5%
	Mixed					8		20.5%
	Epithelioid					5		12.8%
	Not reported					2		5.1%
Cellularity	Low					1		2.6%
	Moderate					3		7.7%
	Marked					25		64.1%
	Not reported					10		25.6%
Cellular atypia	Mild					23		59.0%
	Moderate					3		7.7%
	Marked					2		5.1%
	Not reported					11		28.2%
Tumor size (cm)		0.8	-	32.0	4.5	6.3	±	5.5
Risk group	Very low					17		43.6%
	Low					11		28.2%
	Intermediate					4		10.3%
	High					2		5.1%
	Not reported					5		12.8%
Mitotic count (/5 mm^2)		1.0	-	14.0	2.0	3.0	±	2.8
Necrosis	Absent					23		59.0%
	Present					14		35.9%
	Not reported					2		5.1%
Lymphovascular invasion	Absent					5		12.8%
	Not reported					34		87.2%
Perineural invasion	Absent					3		7.7%
	Not reported					36		92.3%
Resection margin	Negative (R0)					38		97.4%
	Not reported					1		2.6%
Specimen integrity	Complete					24		61.5%
	Incomplete					4		10.3%
	Not reported					11		28.2%

SD: Standard deviation

Patients with Incomplete Specimen Integrity

All four patients with incomplete specimen integrity underwent laparoscopic wedge resection. The intraoperatively estimated tumor diameters ranged from 3.0 to 4.5 cm; these operative estimates were not used for pathological risk classification. Risk categories were based on the pathological tumor diameter and mitotic count reported in the final pathology reports. Two tumors were classified as very low risk and one as intermediate risk; the risk category was not reported for one patient. Resection margins were negative in three patients and unavailable in one. None received adjuvant imatinib.

Recurrence could be assessed from the follow-up records in three of the four patients, and no recurrence was identified. In the remaining patient, vital status at the last follow-up was known; however, the available records were insufficient to evaluate recurrence, and the patient was therefore not considered recurrence-free. All four patients were alive at their last follow-up, with follow-up durations ranging from 8 to 46 months. Although specimen integrity was reported as incomplete in these four patients, tumor rupture could not be confirmed from the available operative notes and detailed pathology records. Therefore, these cases were not classified as definitive tumor rupture.

Immunohistochemical Findings

CD117 expression was positive in 37 of the 38 evaluable patients (97.4%). DOG1 was positive in all 38 evaluable patients (100%), and CD34 was positive in all 36 evaluable patients (100%). SMA staining was positive in 16 of 35 evaluable patients (45.7%), whereas desmin staining was positive in three of 25 evaluable patients (12.0%). S100 was negative in all 33 patients in whom it was evaluated. CD31 was evaluated in only one patient and was negative.

The Ki-67 proliferation index was available for 37 patients. The mean Ki-67 index was 5.4±4.6%, and the median was 5% (range, 1-20%). Among the 37 evaluable patients, the Ki-67 index was <10% in 30 patients (81.1%) and ≥10% in seven (18.9%). Ki-67 results were unavailable for two patients. No patient had an available molecular mutation analysis result for KIT or PDGFRA. The immunohistochemical findings are presented in Table 5.

Postoperative and Medium-term Follow-up Outcomes

The mean postoperative hospital stay was 5.1±3.0 days, with a median of 4 days (range, 2-20 days). No postoperative complication was documented in 33 patients (84.6%), whereas six (15.4%) had a Clavien-Dindo grade II complication. Three patients (7.7%) received adjuvant imatinib.

Ninety-day mortality occurred in one patient (2.6%). Two patients (5.1%) died during the overall follow-up period, while 37 (94.9%) were alive at their last follow-up. The deaths occurred at 2 and 60 months after surgery. One patient (2.6%) died within 90 days after surgery because of progression of concomitant ovarian cancer. This death was unrelated to the gastric GIST resection or a postoperative surgical complication and was therefore not classified as Clavien-Dindo grade V.

Recurrence status was evaluable in 38 patients, none of whom had documented local, peritoneal, or distant GIST recurrence. One patient with insufficient recurrence information was excluded from the denominator. Because no recurrence event occurred, disease-free and recurrence-free survival estimates were not generated.

The mean observed follow-up duration was 41.8±29.8 months, with a median of 33 months (range, 2-120 months). The median follow-up duration estimated using the reverse Kaplan-Meier method was 42 months.

Kaplan-Meier overall survival was 97.4% (95% confidence interval, 83.2-99.6%) at 12, 24, 36, and 48 months and 86.6% (95% confidence interval, 47.5-97.3%) at 60 months; median overall survival was not reached. The numbers at risk at baseline and at 12, 24, 36, 48, 60, 84, and 120 months were 39, 33, 27, 19, 16, 9, 4, and 1, respectively. Because only nine patients remained at risk at 60 months and the confidence interval was wide, this estimate should be interpreted cautiously. Follow-up outcomes are presented in Table 6 and the survival curve in Figure 2.

Discussion

The principal findings of this series were the achievement of R0 resection in all patients with evaluable margin status, the predominance of very low- and low-risk tumors within the cohort, and the absence of documented recurrence among evaluable patients over a median follow-up of 42 months.

The clinical presentation of gastric GISTs varies according to tumor size, anatomical location and relationship with the gastric mucosa. Abdominal pain was the most common presenting symptom in our series, whereas approximately one-fifth of the patients were diagnosed incidentally in the

Table 5. Immunohistochemical findings of the patients (n=39)

Marker	Evaluated n	Positive n (%)	Negative n (%)	Not reported n
CD117	38	37 (97.4)	1 (2.6)	1
DOG1	38	38 (100.0)	0 (0.0)	1
SMA	35	16 (45.7)	19 (54.3)	4
Desmin	25	3 (12.0)	22 (88.0)	14
CD34	36	36 (100.0)	0 (0.0)	3
S100	33	0 (0.0)	33 (100.0)	6
CD31	1	0 (0.0)	1 (100.0)	38
Marker	**Evaluated n**	**Mean ± SD**	**Median**	**Min-max**
Ki-67 (%)	37	5.4±4.6	5.0	1.0-20.0

CD: Cluster of differentiation, DOG1: Discovered on GIST-1, SMA: Smooth muscle actin, SD: Standard deviation, Ki-67: Ki-67 labeling index. Percentages for positive and negative staining were calculated using the number of patients with an available result for the corresponding marker. Molecular testing for KIT and PDGFRA mutations was not performed in any patient

absence of symptoms. Most tumors were located in the fundus or gastric body, and spindle-cell morphology was the predominant histological pattern. The predominance of low mitotic activity and the classification of 82.4% of patients with an available risk category as very low or low risk may partly account for the absence of recurrence during follow-up (1-3,5,10).

Table 6. Postoperative and medium-term follow-up outcomes of the patients (n=39)

		Min-max	Median	Mean ± SD/n-%		
Length of hospital stay (days)		2.0-20.0	4.0	5.1	±	3.0
Postoperative complication status	No postoperative complication			33		84.6%
	Grade II			6		15.4%
Adjuvant imatinib therapy				3		7.7%
Tumor recurrence				0		0.0%
90-day mortality				1		2.6%
Overall mortality				2		5.1%
Observed follow-up (months)		2.0-120.0	33.0	41.8	±	29.8
Median follow-up by reverse Kaplan-Meier, months			42.0			
24-month overall survival			97.4% (95% CI, 83.2-99.6)			
48-month overall survival			97.4% (95% CI, 83.2-99.6)			
60-month overall survival			86.6% (95% CI, 47.5-97.3)			

Data are presented as mean ± standard deviation (SD), median (minimum-maximum), n (%), n/evaluable n (%), or Kaplan-Meier estimate (95% confidence interval), as appropriate. Recurrence status was available for 38 patients; one patient with missing recurrence information was excluded from the denominator. Because no documented recurrence occurred, disease-free survival and recurrence-free survival were not estimated. Median follow-up was calculated using the reverse Kaplan-Meier method. Only nine patients remained at risk at 60 months; therefore, the 60-month overall survival estimate should be interpreted cautiously.
CI: Confidence interval

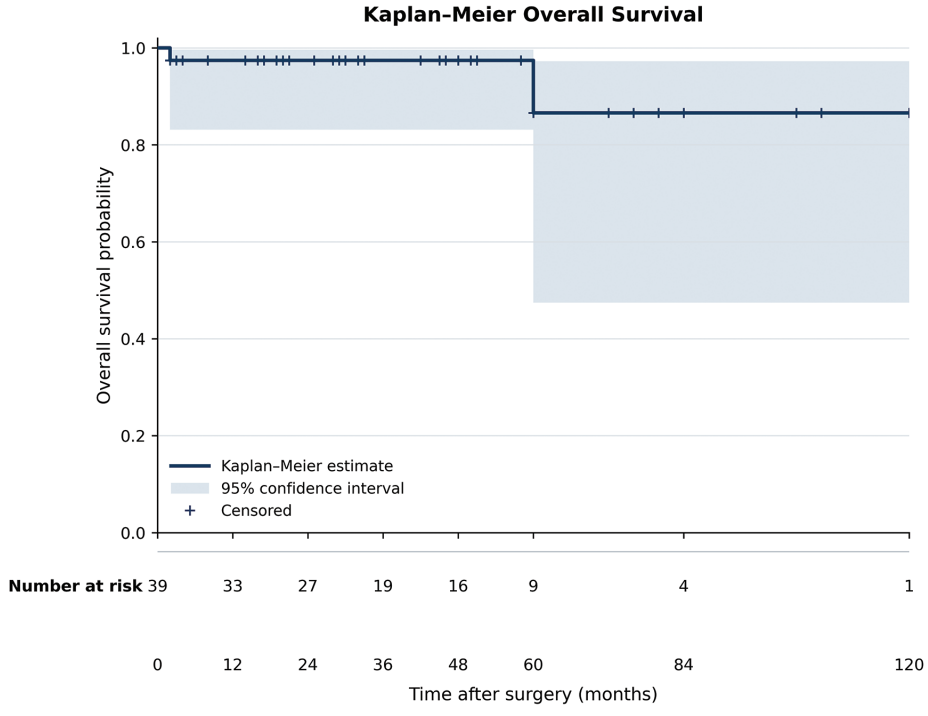

Figure 2. Kaplan-Meier estimate of overall survival after surgical resection for gastric gastrointestinal stromal tumor. The shaded area represents the 95% confidence interval, and vertical marks indicate censored observations. Numbers at risk are presented below the curve

The primary objective of surgery for localized and resectable gastric GIST is to achieve macroscopically complete resection with a microscopically negative margin while preserving the tumor pseudocapsule. The anatomical characteristics of the stomach allow organ-preserving wedge resection to be performed instead of more extensive gastric resection in appropriately located tumors (1-3). In our series, wedge resection was performed in 87.2% of patients, and R0 resection was achieved in all patients with evaluable margin status. These findings indicate that the primary surgical objective was achieved in all patients with evaluable margin status.

A laparoscopic approach was used in 76.9% of the patients. Current guidelines consider minimally invasive surgery appropriate for selected gastric GISTs when tumor integrity and oncological principles can be maintained (1-3). Recent multicenter and national database studies have associated minimally invasive surgery with shorter hospital stay and favorable perioperative outcomes, while suggesting comparable oncological outcomes in appropriately selected patients (7,8,13). However, these studies are largely retrospective, and patients undergoing open surgery generally have larger or technically more complex tumors, creating selection bias. Because only nine patients in our cohort underwent open surgery and the approach was not randomized, no assessment of superiority was made. The high laparoscopy rate should therefore be interpreted as institutional patient selection and practice rather than evidence of the superiority of one approach.

The median hospital stay of four days was generally consistent with contemporary gastric GIST surgery series (8,13). According to the available records, no postoperative complication was documented in 33 patients, whereas six had a Clavien-Dindo grade II complication. The patient who died within 90 days died from progression of concomitant ovarian cancer rather than a surgical complication and was therefore not classified as Clavien-Dindo grade V. However, limited retrospective information regarding the type, treatment, and duration of the grade II complications precluded a comprehensive assessment of perioperative outcomes.

Tumor rupture is an independent and clinically important risk factor for recurrence and may directly influence risk classification and decisions regarding adjuvant therapy (1-3,11). Specimen integrity was reported as incomplete in four patients; however, tumor rupture could not be confirmed from the available operative and pathological records. Accordingly, these cases were not classified as definitive tumor rupture. None of these four patients received adjuvant imatinib, and no documented recurrence was identified in the three patients with evaluable recurrence data. Nevertheless, the small number of patients, missing recurrence information for one patient, and limited follow-up durations of 8-46 months preclude any prognostic interpretation. This observation emphasizes the importance of documenting tumor integrity and any potential rupture event using standardized definitions at the time of surgery (11).

Among evaluable patients, CD117 positivity was 97.4%, whereas DOG1 and CD34 were positive in 100%. These results are consistent with the established immunophenotype of gastric GISTs and support the histopathological diagnoses (1-3,5), but they are expected diagnostic findings rather than an original contribution. The limited assessment of lymphovascular and perineural invasion and missing information on risk classification and specimen integrity restricted the pathological assessment. Current guidelines recommend standardized reporting of molecular characteristics together with tumor size, anatomical location, mitotic activity, margin status, and tumor rupture (1-3,14).

Study Limitations

The absence of KIT and PDGFRA mutation analysis was a major limitation. Molecular classification is a central component of contemporary GIST management because it informs imatinib sensitivity, identifies subgroups with primary resistance, and guides tyrosine kinase inhibitor selection (1-4,6,14,15). Certain PDGFRA mutations are associated with primary imatinib resistance, whereas the type of KIT mutation may affect the expected treatment benefit (1-3,15). Although three patients received adjuvant imatinib, its molecular appropriateness could not be assessed. Long-term trial data support three years of adjuvant imatinib in patients with high-risk, imatinib-sensitive GIST (15,16); however, these findings cannot be directly applied to our patients because mutation status, treatment duration, and adherence were incompletely documented.

Variability in follow-up duration was addressed using the reverse Kaplan-Meier method. Because no documented recurrence occurred among evaluable patients, a recurrence-free survival curve was not presented; only deaths from any cause were treated as events in the overall survival analysis.

The predominance of very low- and low-risk tumors within the cohort may partly explain the absence of recurrence during follow-up. Nevertheless, late recurrence has been reported even in patients with low-risk GIST. In a large series from the Italian Sarcoma Group, recurrence occurred in 5.7% of patients with low-risk GIST (17), whereas Berndsen et al. (18) reported highly favorable long-term disease-specific outcomes after complete resection of non-high-risk GISTs. Thus, although our findings support favorable medium-term oncological control, they do not exclude the possibility of late recurrence.

The five-year overall survival estimate should be interpreted cautiously because only nine patients remained at risk at 60 months and the corresponding confidence interval was wide. Moreover, overall survival included deaths from any cause; therefore, the observed deaths could not be attributed directly to GIST. For these reasons, the findings should be regarded as medium-term real-world outcomes rather than evidence of long-term survival.

The principal contribution of this study is its description of organ-preserving surgical practice and medium-term outcomes in a consecutive cohort of patients with histopathologically confirmed gastric GIST, supported by an appropriate follow-up analysis. The retrospective single-center design, limited sample, missing pathological data, and absence of molecular testing restrict generalizability. Conversely, the inclusion of only confirmed gastric GISTs, transparent use of evaluable denominators, and presentation of survival estimates with the corresponding numbers at risk are methodological strengths.

Conclusion

This single-center series demonstrates that organ-preserving wedge resection was frequently feasible in selected patients with localized gastric GIST and that R0 resection was achieved in all patients with evaluable margin status. Although no documented recurrence was identified during medium-term follow-up, the predominance of low-risk tumors, limited sample size, and declining numbers of patients at risk at later time points preclude firm conclusions regarding long-term oncological effectiveness. These findings support individualizing the surgical approach and extent of resection according to tumor anatomy and the feasibility of preserving tumor integrity, together with standardized documentation of pathological and molecular data.

Ethics

Ethics Committee Approval: The study was approved by the Local Clinical Research Ethics Committee of University of Health Sciences Turkey, İstanbul Bakırköy Dr. Sadi Konuk Training and Research Hospital before its initiation (approval date: June 19, 2026; decision no: 2026-14-26).

Informed Consent: Written informed consent for the use of clinical data for research purposes was obtained from all patients before their inclusion in the study.

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Footnotes

Authorship Contributions

Surgical and Medical Practices: N.Ş., T.D., M.S.D., F.T.Ö., A.M., D.K., A.S., Concept: N.Ş., T.D., S.B., A.S., Design: N.Ş., M.S.D., A.M., Data Collection or Processing: N.Ş., D.K., A.S., Analysis or Interpretation: N.Ş., F.T.Ö., S.B., Literature Search: N.Ş., M.S.D., F.T.Ö., Writing: N.Ş., T.D., M.S.D., F.T.Ö., S.B., A.M., D.K., A.S.

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References

1. Serrano C, Martín-Broto J, Asencio-Pascual JM, López-Guerrero JA, Rubió-Casadevall J, Bagué S, et al. 2023 GEIS guidelines for gastrointestinal stromal tumors. Ther Adv Med Oncol. 2023;15:17588359231192388.
2. Casali PG, Blay JY, Abecassis N, Bajpai J, Bauer S, Biagini R, et al. Gastrointestinal stromal tumours: ESMO-EURACAN-GENTURIS Clinical Practice Guidelines for diagnosis, treatment and follow-up. Ann Oncol. 2022;33(1):20-33.
3. Hirota S, Tateishi U, Nakamoto Y, Yamamoto H, Sakurai S, Kikuchi H, et al. English version of Japanese Clinical Practice Guidelines 2022 for gastrointestinal stromal tumor (GIST) issued by the Japan Society of Clinical Oncology. Int J Clin Oncol. 2024;29(6):647-680.
4. von Mehren M, Kane JM, Riedel RF, Sicklick JK, Pollack SM, Agulnik M, et al. NCCN Guidelines® insights: gastrointestinal stromal tumors, version 2.2022. J Natl Compr Canc Netw. 2022;20(11):1204-1214.

5. Blay JY, Kang YK, Nishida T, von Mehren M. Gastrointestinal stromal tumours. Nat Rev Dis Primers. 2021;7(1):22.

6. Serrano C, Álvarez R, Carrasco JA, Marquina G, Martínez-García J, Martínez-Marín V, et al. SEOM-GEIS clinical guideline for gastrointestinal stromal tumors (2022). Clin Transl Oncol. 2023;25(9):2707-2717.

7. Park SH, Lee HJ, Kim MC, Yook JH, Sohn TS, Hyung WJ, et al. Early experience of laparoscopic resection and comparison with open surgery for gastric gastrointestinal stromal tumor: a multicenter retrospective study. Sci Rep. 2022;12(1):2290.

8. Crocker AB, Vega EA, Kutlu OC, Salehi O, Mellado S, Li M, et al. Is minimally invasive surgery for large gastric GIST actually safe? A comparative analysis of short- and long-term outcomes. Surg Endosc. 2022;36(9):6975-6983.

9. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP; STROBE Initiative. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. Ann Intern Med. 2007;147(8):573-577.

10. Joensuu H. Risk stratification of patients diagnosed with gastrointestinal stromal tumor. Hum Pathol. 2008;39(10):1411-1419.

11. Nishida T, Hølmebakk T, Raut CP, Rutkowski P. Defining tumor rupture in gastrointestinal stromal tumor. Ann Surg Oncol. 2019;26(6):1669-1675.

12. Schemper M, Smith TL. A note on quantifying follow-up in studies of failure time. Control Clin Trials. 1996;17(4):343-346.

13. Freeman HD, Mudgway R, Tran Z, Kim R, Lum SS, Namm JP, et al. Oncologic outcomes and survival of modern surgical approaches for gastric gastrointestinal stromal tumor (GIST). Surg Endosc. 2024;38(11):6854-6864.

14. Judson I, Jones RL, Wong NACS, Dileo P, Bulusu R, Smith M, et al. Gastrointestinal stromal tumour (GIST): British sarcoma group clinical practice guidelines. Br J Cancer. 2025;132(1):1-10.

15. Joensuu H, Wardelmann E, Eriksson M, Reichardt A, Sundby Hall K, Schütte J, et al. KIT and PDGFRA mutations and survival of gastrointestinal stromal tumor patients treated with adjuvant imatinib in a randomized trial. Clin Cancer Res. 2023;29(17):3313-3319.

16. Joensuu H, Eriksson M, Sundby Hall K, Reichardt A, Hermes B, Schütte J, et al. Survival outcomes associated with 3 years vs 1 year of adjuvant imatinib for patients with high-risk gastrointestinal stromal tumors: an analysis of a randomized clinical trial after 10-year follow-up. JAMA Oncol. 2020;6(8):1241-1246.

17. D'Ambrosio L, Fumagalli E, De Pas TM, Nannini M, Bertuzzi A, Carpano S, et al. Guideline-based follow-up outcomes in patients with gastrointestinal stromal tumor with low risk of recurrence: a report from the Italian Sarcoma Group. JAMA Netw Open. 2023;6(11):e2341522.

18. Berndsen M, Renberg S, Hølmebakk T, Hancke E, Puls F, Karlsson F, et al. Long-term outcome after surgical resection of non-high-risk gastrointestinal stromal tumours without adjuvant therapy. Br J Surg. 2023;110(12):1857-1862.