

Efficacy and Safety of Advanced Endoscopic Resection Techniques for Gastrointestinal Subepithelial Lesions: A Middle East Multicenter Experience

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Abstract

Background

Advanced endoscopic resection has revolutionized the management of gastrointestinal subepithelial lesions (SELs), offering a minimally invasive alternative to surgery. While high-volume data from East Asia and the West establishes its efficacy, large-scale multicenter outcomes from the Middle East remain unreported.

Objectives

This study aimed to evaluate the efficacy and safety of advanced endoscopic resection techniques for SELs across multiple tertiary centers in the Middle East.

Methods

We conducted a multicenter, retrospective analysis of 104 patients who underwent endoscopic resection; endoscopic submucosal dissection (ESD), submucosal tunneling endoscopic resection (STER), and endoscopic full-thickness resection (EFTR), for SELs between July 2019 and July 2025 across six hospitals. The primary outcome was the R0 resection rate. Secondary outcomes included complication rates and analysis of clinical variables.

Findings:

The histologically confirmed R0 resection rate was 96.9% (95/98). The overall complication rate was 14.4% (15/104), comprising intraprocedural bleeding (4.8%) and perforation (5.8%), all managed endoscopically with a 0% surgical conversion rate. No statistically significant association was found between complete resection rate and procedure type ($p = 0.17$), lesion location ($p = 0.41$), or EUS layer of origin ($p = 0.99$).

Conclusions

This first multicenter Middle Eastern study demonstrates that advanced endoscopic resection is highly effective and safe for GI SELs, achieving excellent oncologic outcomes with definitive endoscopic management of complications. These results support adopting these techniques as a first-line, organ-preserving treatment in the region.

Introduction

The American College of Gastroenterology (ACG) clinical guideline describes subepithelial lesions (SELs) as masses or mass-like structures projecting into the gastrointestinal (GI) lumen, typically arising from a non-mucosal layer including the muscularis mucosae, submucosa, muscularis propria, and serosa, within the GI tract wall (1). Clinically, SELs present as non-neoplastic, neoplastic but benign, neoplastic harboring malignant potential, or overtly malignant (about 15% of all identified cases) (2–4). Moreover, investigations into the incidence of SELs identify these protrusions as primarily asymptomatic, especially when they are small (4). However, larger SELs (> 2 cm) have been associated with incidences of dysphagia, overt or occult GI bleeding, and chronic anemia (5, 6).

About two-thirds of SELs present in the stomach appear as small, often less than 2 cm, protrusions with normal mucosa (3, 7). SELs embody a broad range of entities, including gastrointestinal stromal tumors (GISTs), leiomyomas, pancreatic rests, carcinoid (neuroendocrine) tumors (NETs), lipomas, cysts, and lymphomas (1, 4). While leiomyomas and granular cell tumors, lipomas and fibromas are primarily benign, carrying very low risk, GISTs, NET, glomus tumors, and lymphomas are commonly malignant or potentially malignant (8, 9). Consequently, the accurate diagnosis and appropriate management of these lesions remain a central challenge in modern gastroenterology, with Kim et al. attributing this challenge to their sub-epithelial location (5).

Historically, the management of SELs suspected for neoplasia or potentially malignant SELs, particularly GISTs and other mesenchymal tumors, has been predominantly surgical, involving segmental resection via laparotomy or laparoscopy (5, 10, 11). However, while effective, surgical resection is associated with significant morbidity, extended hospital stays, higher medication costs, and impaired quality of life (12, 13). Since the advent of endoscopic ultrasonography (EUS) in the early 1980s, followed by the introduction of fine-needle aspiration (FNA) in the early 1990s, EUS has significantly revolutionized the detection and management of SELs by allowing for detailed characterization of the

lesion's layer of origin, size, and echogenic features (14–16). Consequently, leveraging insights from Varanese et al., this documented diagnostic precision has paved the way for the development of advanced therapeutic endoscopic techniques, offering a minimally invasive alternative to surgery for carefully selected SELs (16).

Despite growing global literature on the efficacy and safety of these advanced techniques, the vast majority of published data originates from East Asia, Europe, and North America (17–19). Notably, insights from Naofa et al. place the Middle East as a unique clinical and epidemiological landscape where factors such as genetic diversity, regional variations in disease presentation, differences in healthcare infrastructure, and the evolving expertise in tertiary referral centers may influence procedural outcomes (20–22). Coincidentally, recent studies indicate that while advanced EUS techniques, including endoscopic submucosal dissection (ESD), submucosal tunneling endoscopic resection (STER), and endoscopic full-thickness resection (EFTR), are effective for treating GI-SELs, a significant gap exists in large-scale, multicenter data evaluating their real-world application, particularly regarding long-term outcomes and standardized complication management (13, 23, 24).

Thus, this multicenter study was conducted with the aim of addressing this critical knowledge gap by presenting a comprehensive, retrospective analysis from six tertiary centers in the Middle East. This paper seeks to evaluate the efficacy and safety of advanced endoscopic resection techniques for SELs. By contributing a substantial regional experience, this study aims to validate the role of these minimally invasive techniques within the Middle Eastern clinical context and inform best practices for their adoption and implementation.

Materials and Methods

Study Design

This multicenter, retrospective, observational study was conducted across six ($n = 6$) tertiary care hospitals in the Middle East, specifically, Egypt, the United Arab Emirates, Saudi Arabia, Jordan, and Iraq. The study period spanned sixty months ($n=60$ months) from July 2019 to July 2025. This manuscript was prepared in strict adherence to the Strengthening and Reporting of Observational Studies in Epidemiology (STROBE) recommendations for cohort studies as iterated by von Elm et al. (25, 26).

Ethical Considerations

The study protocol received ethical approval from the Institutional Review Board (IRB) at Ethical approval was obtained from Imam Abdulrahman Bin Faisal University, in compliance with the principles of the World Medical Association Declaration of Helsinki (IRB-20260-1-0298). The need for individual patient informed consent was waived due to the retrospective nature of the study, though all procedures were performed initially following standard clinical consent processes.

Study Population and Eligibility Criteria

Adult patients (aged ≥ 18 years) who underwent advanced endoscopic resection for a gastrointestinal SEL during the study period were eligible for inclusion. Patients were identified through endoscopic and surgical databases at each center.

Inclusion Criteria:

- Diagnosis of a GI subepithelial lesion ≥ 1 cm in size, or < 1 cm with high-risk features (symptomatic, ulcerated, or with suspicious EUS characteristics).
- Lesion deemed suitable for endoscopic resection following multidisciplinary team evaluation.
- Performance of an advanced endoscopic resection technique (ESD, STER, or EFTR).
- Availability of complete procedural and histopathological records.

Exclusion Criteria:

- Lesions treated with simple polypectomy or mucosal resection.
- Patients undergoing direct surgical resection without an attempted endoscopic procedure.
- Incomplete medical records or loss to follow-up immediately post-procedure.

Sample Size Calculation

The sample size was estimated *a priori* using Epi Info software (Version 7.2, CDC, Atlanta, GA). Assuming a gastrointestinal SEL prevalence of approximately 1% in the referred population, a 95% confidence level, and a 5% margin of error, a minimum sample size of 90 patients was calculated. Anticipating potential incomplete records, we aimed for a larger sample, ultimately including 105 consecutive patients who met the eligibility criteria.

Pre-Procedural Assessment and Patient Selection

All patients underwent a standardized pre-procedural evaluation. The assessment included a high-definition white-light endoscopy and, in all cases, either endoscopic ultrasonography (EUS) or contrast-enhanced computed tomography (CT) of the abdomen/pelvis. EUS was prioritized for lesions amenable to evaluation (e.g., esophageal, gastric, rectal) to assess the layer of origin, size, echotexture, and presence of high-risk features. Cross-sectional imaging was used for large lesions or those in anatomic locations less accessible to EUS. The final decision for endoscopic resection was made by a multidisciplinary tumor board, considering lesion characteristics (size, location, growth rate, preliminary histology if available), patient comorbidities, and patient preference after detailed counseling on risks, benefits, and alternatives (surgery or surveillance).

Endoscopic Resection Procedure

All procedures were performed by accredited, high-volume gastroenterologists with formal training in third-space endoscopy techniques. Procedures were conducted under general anesthesia with endotracheal intubation administered by a consultant anesthesiologist.

1. Patient Positioning & Equipment

Patients were positioned optimally to leverage gravity (typically left lateral or prone) to minimize luminal content spillage in case of perforation. A single-channel adult gastroscope or pediatric colonoscope (GIF-HQ190/Q180, CF-HQ190I; Olympus, Japan) with a water-jet system was used. Carbon dioxide insufflation was maintained via a microprocessor-controlled electrosurgical generator (ERBE VIO3 or VIO300D; ERBE, Tübingen, Germany).

2. Submucosal Injection

The submucosal cushion was created using a mixture of ORISE™ Gel (Boston Scientific, USA) or 0.9% saline, stained with indigo carmine or methylene blue, and combined with diluted epinephrine (1:100,000) to enhance hemostasis.

Resection Technique

The specific technique (ESD, STER, or FTA/ EFTR) was chosen based on lesion location and origin layer. The principal electrosurgical knives used were the Dual Knife J (Olympus, Japan) or the Hybrid Knife (ERBE, Germany). The resection was performed using a combination of endoscopic knives and hemostatic forceps (Coagrasper, Olympus) for precise dissection and vessel coagulation. The goal was *en bloc* resection. Significant intra-procedural bleeding was managed with hemostatic forceps or hemostatic clips.

Histopathological Evaluation

Resected specimens were retrieved, pinned on a corkboard to preserve orientation, and fixed in 10% neutral buffered formalin. Histopathological assessment was conducted by experienced, board-certified gastrointestinal pathologists at each institution. A standardized report included:

- Macroscopic description and lesion dimensions.
- Final histological diagnosis (e.g., GIST, leiomyoma, schwannoma, etc.).
- Mitotic index (for GISTs).
- Assessment of lymphovascular invasion.
- Evaluation of lateral and deep (vertical) resection margins, reported in millimeters.

Post-Procedural Management and Follow-up

Patients were admitted for post-procedural observation. Management included intravenous fluids and a high-dose proton pump inhibitor (PPI) for upper GI lesions. A liquid diet was initiated after 12–24 hours, advancing to a soft diet within 48 hours if no complications occurred. Patients were monitored for signs of bleeding, perforation, or infection. Discharge criteria were stable vital signs, tolerance of oral intake, and absence of complications.

Study Definitions and Outcome Measures

The primary outcome measure for this study was the rate of R0 resection. R0 resection was defined as the *en bloc* removal of the subepithelial lesion with histologically confirmed tumor-free lateral (horizontal) and deep (vertical) margins upon pathological examination. This outcome was contingent upon the prior achievement of an en bloc resection, which was defined as the removal of the entire lesion in a single, uninterrupted specimen.

Procedural success was defined as the successful completion of the intended endoscopic resection, specifically the accomplishment of an *en bloc* resection, without the necessity for conversion to emergent surgical intervention due to a complication or technical failure.

Safety was assessed through the analysis of procedure-related complications, which were classified as either immediate (intraprocedural) or delayed (occurring up to 30 days post-procedure). Bleeding was categorized as a significant hemorrhage that required an endoscopic intervention for control (e.g., hemostatic forceps, clipping) or a blood transfusion. Perforation was defined as a macroscopic, full-thickness defect in the gastrointestinal wall identified during the procedure or in the postoperative period. Other recorded complications included, but were not limited to, local infection, symptomatic stenosis, and aspiration pneumonia. For the overall safety analysis, all intraoperative and postoperative adverse events recorded within the 30-day window were combined.

Results

Patient Demographics

This multicenter study retrospectively assessed a total of 104 patients – 54 (51.9%) male and 50 (48.1%) female – who underwent advanced endoscopic resection for selected GI subepithelial lesions. The mean age of the patients was 49.93 ± 14.21 years (ranging from 24 to 85). Patients were presented with various comorbidities, including diabetes mellitus (DM) in 30 (29.7%) of patients, 34 (33.7%) had hypertension, and 10 (10.2%) had ischemic heart disease (IHD). Coagulation was present in only 10 (11.2%) of patients, while no patients had inflammatory bowel disease [Figure 1].

Anatomically, lesions were primarily distributed as follows: upper esophagus (11.2%), middle esophagus (7.1%), lower esophagus (7.1%), proximal stomach (40.0%), distal stomach (19.4%), duodenum (7.7%), colon (2.0%), and rectum (8.2). Histopathological examination identified the following as the predominant tumors: neuroendocrine tumors (NETs) (36.5%), leiomyomas (22.1%), gastrointestinal stromal tumors (GISTs) (15.4%), and lipomas (10.6%). Table 1 details the demographic and clinical characteristics of the patients who were included in this retrospective study.

Table 1
Demographic details of included patients

Variable		Mean	SD
Age		49.93	14.21
		N	%
Gender	Female	54	51.9
	Male	50	48.1
Diabetes mellitus	Present	30	29.7
	Absent	71	68.3
Hypertension	Present	34	33.7
	Absent	67	66.3
Inflammatory bowel disease	Absent	98	100
Ischemic heart disease	Present	10	10.2
	Absent	88	89.8
Anticoagulant	Yes	10	11.2
	No	87	88.8
Previous intervention	Yes	6	6.1
	No	92	93.9
Lesion location	Upper esophagus	11	11.2
	Middle esophagus	7	7.1
	Lower esophagus	7	7.1
	Proximal stomach	40	40.0
	Distal stomach	19	19.4
	Duodenum	8	7.7
	Colon	2	2.0
	Rectum	8	8.2
Tumors identified	Leiomyoma	23	22.1
	Neuroendocrine tumors	38	36.5
	Gastrointestinal stromal tumors	16	15.4
	Inflammatory fibroid polyp (IFP)	7	6.7
	Pancreatic rest	3	2.9
	Lipoma	11	10.6
	Abscess	1	1.0
	Schwannoma	1	1.0
	Granular cell tumor	4	3.8

Efficacy outcomes

Complete RO endoscopic resection

The overall RO resection rate was 95 (96.9%). The resection rate differed according to procedure type, location of lesions, and EUS layer. According to procedure type, endoscopic submucosal dissection (ESD) had a higher complete resection rate, 57 (60.0%), compared to

submucosal tunneling endoscopic resection (STER), 23 (24.2%), laparoscopic assisted 2 (2.1%), and full-thickness assisted (FTA) 13 (13.7%). Despite the variation among the procedure types for removing tumors, there was no statistically significant association between procedure type and complete resection rate (Fisher–Freeman–Halton exact test, $p = 0.17$) [Figure 2]. Similarly, there was no statistically significant association between complete resection rate and endoscopic layer ($p = 0.99$) and lesion location ($p = 0.41$). Table 2 presents the association between clinical characteristics and the complete resection rate.

Table 2
The association between clinical variables and complete resection rate

Clinical variables		RO resection rate, N (%)	P value
Endoscopic tumor removing procedures	Submucosal tunnelling endoscopic resection	23 (24.2)	0.17
	Endoscopic submucosal dissection	57 (60.0)	
	Laparoscopic assisted	2 (2.1)	
	Full-thickness assisted	13 (13.7)	
Lesion location	Esophagus	5 (6.7%)	0.41
	Stomach	55 (73.3%)	
	Duodenum	5 (6.7%)	
	Colorectal	10 (13.3%)	
Endoscopic layer	Superficial	35 (57.4%)	0.99
	Muscularis propria	24 (39.3%)	
	Deep/extramural	2 (3.3%)	

Tumor size reduction

The size after was generally smaller compared to the size of tumors before. The analysis showed that endoscopic resection is effective in significantly reducing the size of lesions (Wilcoxon signed-rank test: $Z = -4.470$, $p = 0.0001$; $n = 84$) (Table 3). Even though median lesion sizes before and after remained the same at 20 mm, the paired assessment showed a consistent within-patient reduction [Figure 3].

Table 3
Endoscopic resection techniques in reducing tumor size

	Median	IQR	P values
Size before	20	12–30	0.0001
Size after	20	16–35	

Procedure time

The Kruskal-Wallis test did not show any significant difference in reducing procedure time across procedure type ($H = 6.57$, $df = 3$, $p = 0.09$) and lesion location ($H = 3.02$, $df = 3$, $p = 0.39$) (Table 4).

Table 4
Effectiveness of endoscopic resection techniques in reducing procedural time in comparison to procedure type and location of lesions

Procedure type	H test statistic	df	P value
	6.57	3	0.09
Location of lesions	3.02	3	0.39

Safety outcomes

Complications

The overall complication rate of resection techniques was 15 (14.4%). Specifically, intraoperative bleeding occurred in 5 (4.8%) patients, while intraoperative perforation occurred in 6 (5.8%) of patients. Postoperative complications (delayed bleeding, leak, pneumothorax, and non-fatal pulmonary embolism) were observed in 4 (3.8%) of patients. There was no significant difference in complication rate by location of lesions ($p = 0.18$) and procedure type ($p = 0.95$) (Table 5).

Table 5
Complication rates by location of lesions and procedure type

Variables		Complication rate	P value
Location of lesions	Esophagus	0 (0.0)	0.18
	Stomach	12 (20.7)	
	Duodenum	0 (0.0)	
	Colorectal	0 (0.0)	
Procedure type	Full-thickness resection	1 (8.3)	0.95
	Laparoscopic assisted	0 (0.0)	
	Submucosal tunnelling endoscopic resection	3 (14.3)	
	Endoscopic submucosal dissection	11 (17.5)	

Discussion

This multicenter, retrospective study presents the first comprehensive assessment of advanced endoscopic resection for gastrointestinal subepithelial lesions in the Middle East region. Findings from this analysis reveal that advanced EUS techniques are highly effective and present a safe therapeutic strategy for SELs management in the Middle East, with the modality yielding oncologically sound results with a manageable risk profile, supporting their integration as a first-line treatment in appropriately selected patients.

For the endoscopic management of SELs, achieving RO resection with clear margins for potentially malignant lesions such as GISTs and NETs presents a critical cornerstone in the field (27, 28). This cohort of 104 patients clinically diagnosed with SELs realized a 96.9% RO resection rate from 98 participants, where histopathological data were available. Such a significantly high RO finding is consistent and favorably compares to RO benchmarks in contemporary benchmarks, for instance, in the nationwide multicenter GASTRO trial, which reported technical success, *en bloc* success, and RO success following endoscopic resection of gastric SELs at 97.0%, 94.3%, and 88.9%, respectively (23). Similarly, a Polish multicenter analysis of full-thickness resection of superficial and subepithelial lesions from 105 consecutive procedures reported a 95% RO resection rate, which corresponds closely with observations from this study (29). Moreover, Ohata et al., in an exploration of risk factors associated with endoscopic resection of superficial non-ampullary duodenal epithelial tumors (SNADETs), reported an RO resection rate of 92.4% (30). A recent prospective observational study of 15 consecutive patients with esophagogastric SELs by Akahoshi et al. reported a 88.9% RO resection rate (31) while Li et al., in a retrospective analysis of SELs, reported an 89.8% RO resection rate of duodenal SELs (32).

A key insight realized from this study's high SELs RO resection rate was that these higher rates may reflect a combination of factors, including meticulous multidisciplinary lesion selection, the application of various advanced techniques tailored to specific lesion characteristics, and the concentrated expertise of tertiary referral centers, which could explain these high rates. Nonetheless, this study acknowledges a notable limitation in the lack of systematically recorded *en bloc* resection data, which precludes analysis of its relationship to margin status. However, the exceptionally high RO rate itself serves as a strong surrogate marker of overall procedural efficacy and technical success.

The lack of a statistically significant association between the type of endoscopic procedure and the rate of RO resection ($p = 0.17$) presents a compelling finding underscoring the fundamental principle of modern third-space endoscopy, where more favorable outcomes are achieved through a deliberate, lesion-specific technique in line with assertions from Nabi & Reddy (33).

Based on these insights, this paper articulates that the observed distinctive resection rates, specifically, ESD at 60.0%, STER at 24.2%, and FTA at 13.7%, primarily reflect the prevalence of lesions for which each technique was the appropriate tool, not an inherent difference in efficacy. Thus, we postulate that this tailored strategy, governed and guided by meticulous EUS staging as detailed in this study's methodology, was a crucial driver for the overall high RO rate realized in this context.

The overall complication rate realized in this study's cohort was 14.4% (15/104), lying between the expected range of complications for these complex procedures. Notably, compared to the GASTRO trial and a retrospective analysis of 634 endoscopic submucosal dissection cases by Santos-Antunes et al., which reported an overall complication rate of 6.3% and 0.4%, respectively, this rate is significantly higher (23, 34). However, this finding aligns more closely with observations from other series, as seen in the 13% incidence of procedure-related adverse events in 58 patients undergoing EUS resection by Verloop et al. (35) and Rogalski et al., reporting an 11% occurrence of clinical adverse events (29).

Based on this assertion, this paper posits that the nature and outcome of the complication are as crucial as their observed frequency. Thus, in this context, all intraprocedural events, specifically, bleeding (4.8%) and perforation (5.8%), were successfully managed through endoscopic techniques, resulting in a 0% rate of emergent surgical conversion. This finding differs significantly from Verloop et al.'s observation of 12% of adverse events requiring additional surgery (35). Notably, the incidence of intraoperative perforation rate, 5.8% is consistent with results realized from Li et al. reporting a 4.1% delayed perforation rate in duodenal SELs which is in line with previous findings by Kim et al.(36), Ye et al.(37), Watanabe et al.(38) and Kim et al. (39). The successful endoscopic resolution of all intraoperative adverse events underscores a key principle in modern therapeutic endoscopy as noted by Mandarino et al., in that under expert hand, the inherent risks of advanced resection are manageable through proficient endoscopic salvage, affirming the procedure's safety (40). Moreover, the lack of a significant association between complication rates and either procedural type or lesion location suggests that risks are more closely tied to individual lesion complexity and operator skill(41–43).

Limitations

Over the course of this study, we realized and acknowledge several critical limitations that warrant careful consideration when conclusively interpreting the findings presented.

Firstly, the retrospective, observational design adopted by this study presents a key source of selection bias and unquantified confounding. Specifically, despite our inclusion of a consecutive patient cohort, the fundamental decision to pursue EUS resection for SELs was made by a multidisciplinary team at the recorded tertiary centers, likely selecting for SELs with favorable anatomy and patients with adequate physiological reserve. This limitation may strangle the generalizability of the previously established outstanding safety and efficacy outcomes to broader, less-selected community populations or to SELs with more challenging characteristics.

Secondly, the absence of systematically recorded data on en bloc compared to piecemeal resection presented a dire constraint to the finding asserted in this study. Despite the RO resection rate serving as the ultimate oncologic endpoint, the en bloc resection rate is a critical quality indicator of endoscopic techniques as literature in the field suggests an association of piecemeal resection with higher recurrence rates (2–3% in en bloc compared to 10–20% in piecemeal resections) in certain tumors and its capacity to complicate pathological margin assessment in these tumors (44–47). Thus, this study's inability to report or analyze the en bloc resection rates precludes a fuller evaluation of the technical quality of resections across the different procedural modalities articulated in this analysis.

Moreover, the medium-term follow-up period, n = 60 months, presents an often overlooked constraint in EUS resection analysis, which is the challenge presented in evaluating the primary oncologic endpoint for SELs with malignant potential (48). According to Iwamuro et al., while EUS presents an excellent and established efficacy for diagnosis and assessing the layers of origin (often in the 4th layer for GISTs), determining the precise malignant risk before, during, and after resection is clinically challenging (49). Thus, while the 60-month mark presents a pivotal hallmark, this mark is sometimes insufficient to determine if a "completed" resection has permanently eliminated the risk of metastatic progression as observed by Niederle & Niederle (50), Minoda et al. (51), and Chantarojanasiri et al. (52). Thus, the lack of protocol-driven long-term follow-up necessitates the interpretation of this study's findings with appropriate caution regarding their long-term durability.

Lastly, despite the multicenter design being a key strength for patient accrual and generalizability, this design is an inherent source for potential heterogeneity, presented explicitly in the variations in procedural techniques, perioperative management protocols, and histopathological assessments between participating institutions as asserted by Das (53). These institutions, despite being high-volume tertiary centers, may report influenced outcomes, warranting the need for standardized prospective registries with centralized pathology review to mitigate this source of variability fully.

Conclusions

Based on evidence presented in this long-term multicenter analysis of the efficacy of advanced endoscopic resection techniques for SELs, this paper conclusively asserts endoscopic techniques as highly effective and safe therapeutic paradigms for SELs in the Middle East. This assertion is robustly supported by the realization of a 96.9% RO resection range within a heterogeneous cohort. Moreover, this paper

highlights that when coupled with meticulous pre-procedural planning, EUS can deliver exceptional oncologic outcomes across a divergent spectrum of lesion location and pathologies. Additionally, the demonstrated safety profile, characterized by a zero percent rate of emergent surgical conversion despite an expected spectrum of intraprocedural adverse events, firmly establishes these procedures as definitive organ-preserving treatments within expert tertiary centers.

For clinical practice, this study strongly advocates for the formal integration of advanced endoscopic resection as a first-line treatment option for manageable SELs, potentially reducing reliance on more invasive surgical interventions. Future research should prioritize prospective, randomized designs with protocol-driven long-term surveillance to definitively establish the durability of resection, particularly for lesions with malignant potential. Further investigation into standardized algorithms for technique selection based on EUS criteria and comparative cost-effectiveness analyses is also highly recommended.

Declarations

Funding Declaration:

No funding was received for this review.

Ethics, Consent to Participate, and Consent to Publish declarations:

The study protocol received ethical approval from the Institutional Review Board (IRB) at Ethical approval was obtained from Imam Abdulrahman Bin Faisal University, in compliance with the principles of the World Medical Association Declaration of Helsinki. (IRB-20260-1-0298).

The need for individual patient informed consent was waived due to the retrospective nature of the study, though all procedures were performed initially following standard clinical consent processes.

Conflict of Interest:

Nothing to declare

Data availability:

The authors confirm that the data supporting the findings of this study are available within the article.

Authors' contribution:

Concept and design of the study A.M., E.G.; Literature search and data collection: A.F., E.G., A.A., B.M.; Endoscopic Procedures and Consenting A.M., A.F.; Analysis and interpretation of data: E.G., B.M., A.A.; Drafting of the manuscript: E.G., A.M.; Critical revision of the manuscript for important intellectual content: E.G., A.M., A.F., A.A.; Supervision: E.G.

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Figures

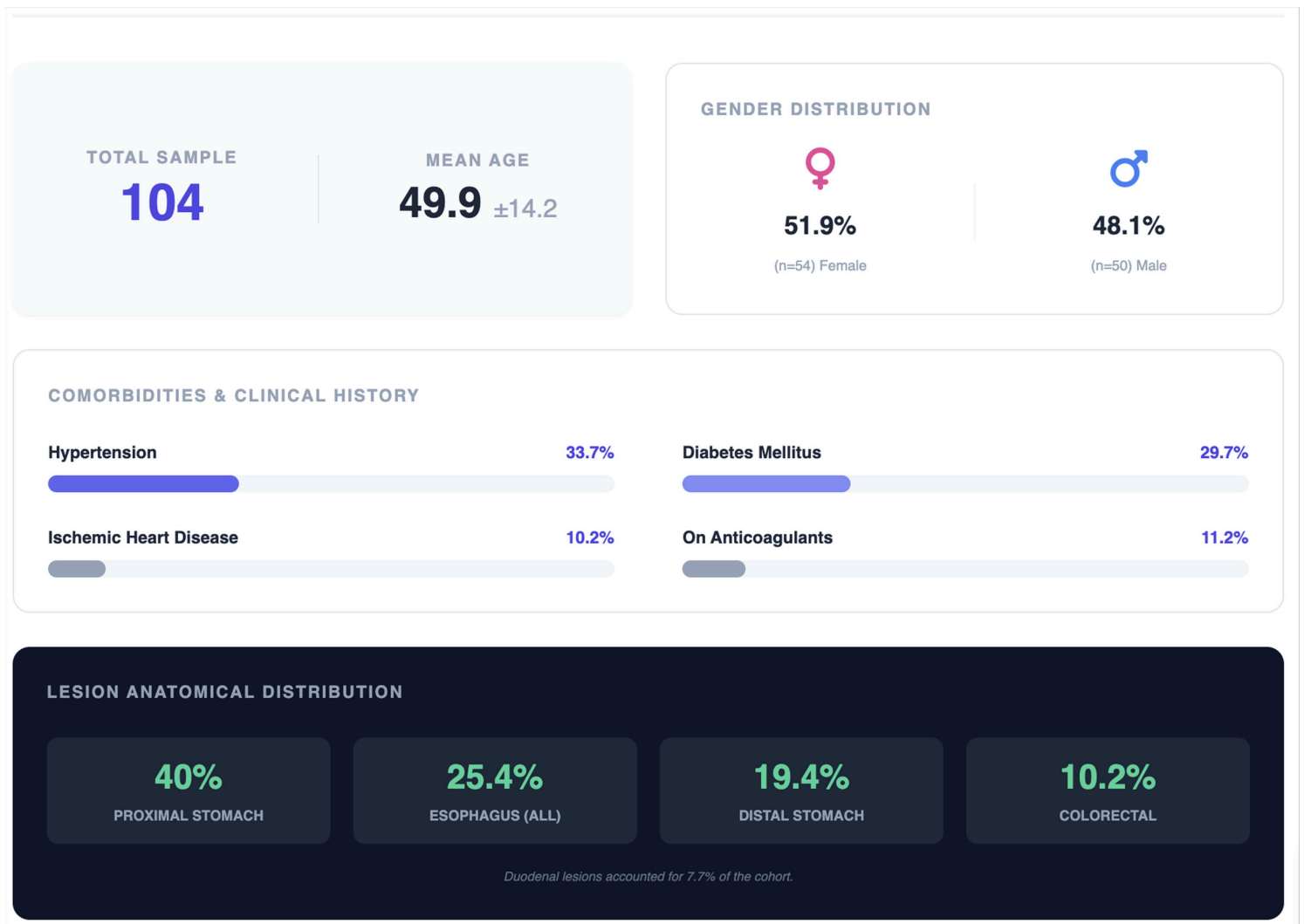


Figure 1

Patient Demographics

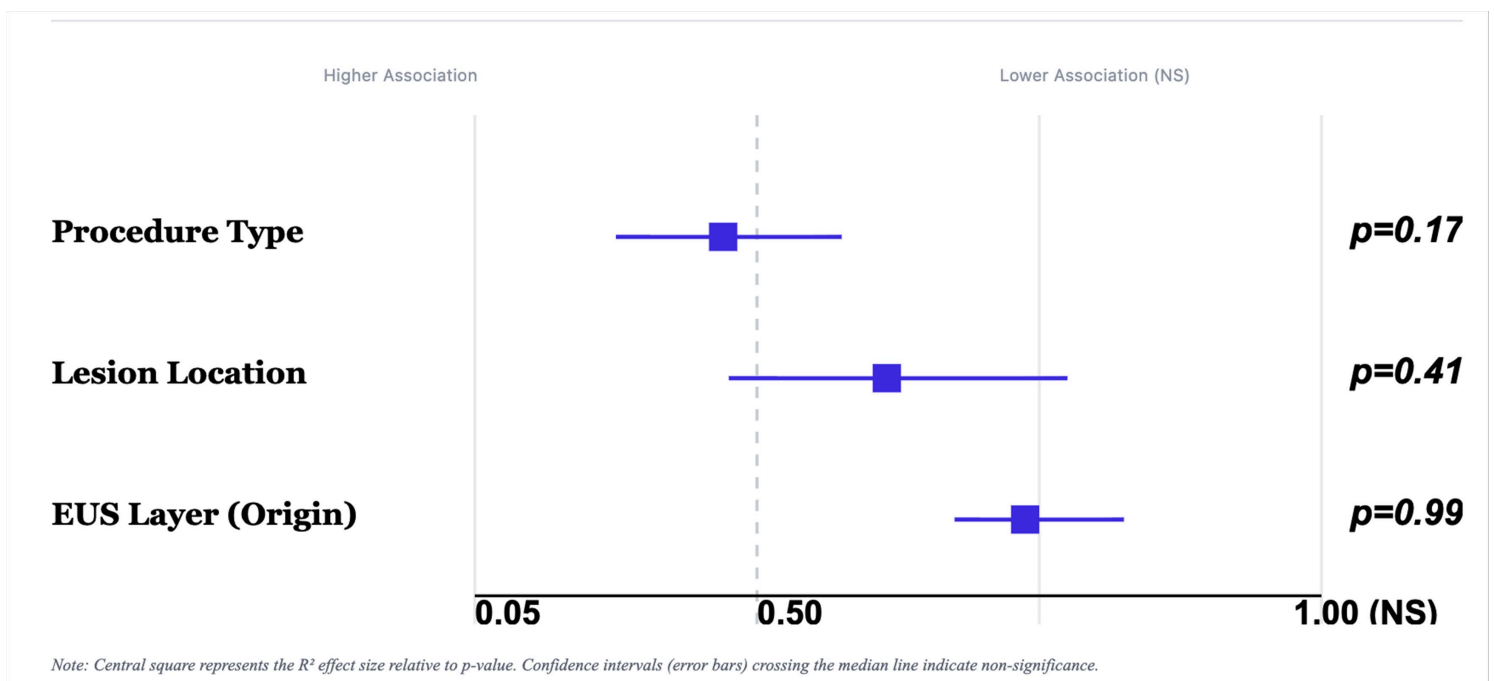


Figure 2

Forest Plot of Clinical Variable Associations (p-values)

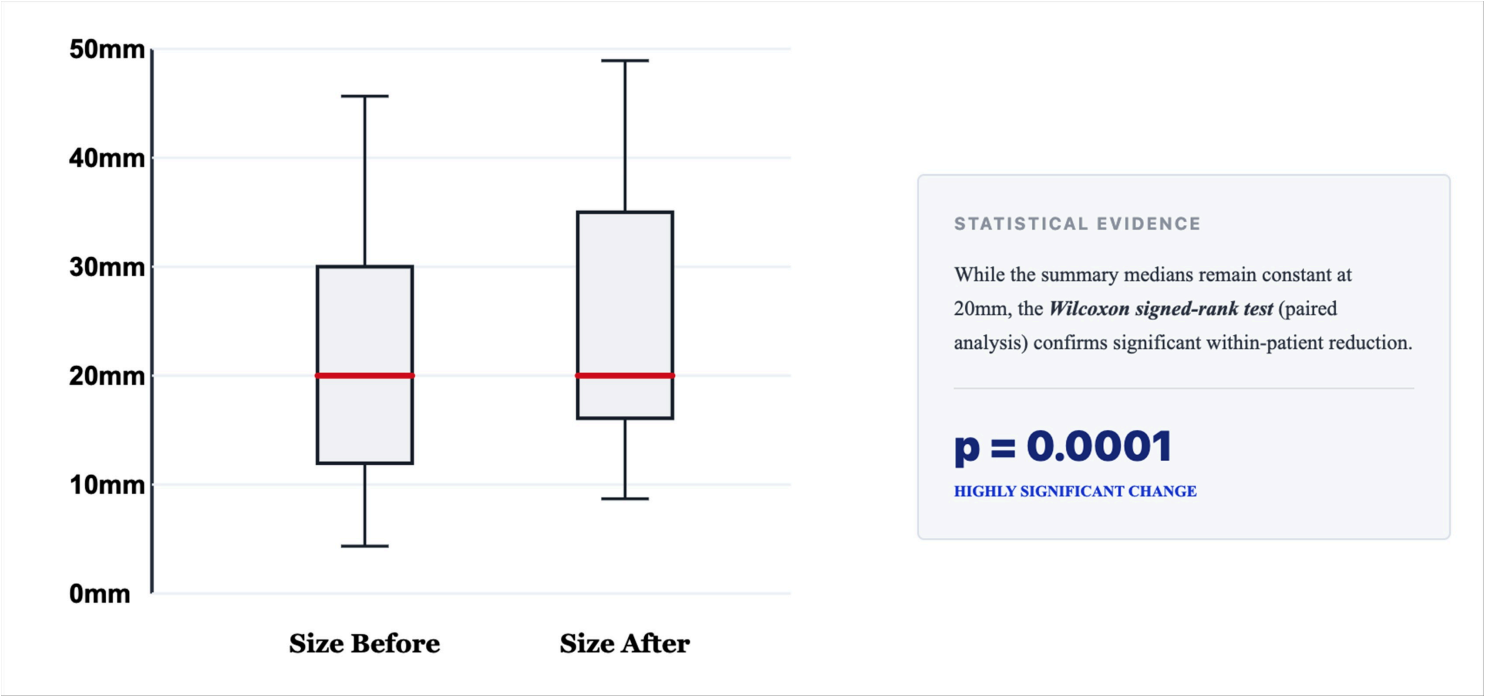


Figure 3

Lesion Size Characteristics (Pre vs. Post Procedure)