

Comparative efficacy of combinations of endoscopic classifications and recurrence models for large colorectal laterally spreading tumors

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A – research concept and design; B – collection and/or assembly of data; C – data analysis and interpretation; D – writing the article; E – critical revision of the article; F – final approval of the article

Keywords:

laterally spreading tumor, endoscopic classification, histology prediction, recurrence, colorectal neoplasia.

Ключові слова:

пухлина, що поширюється латерально, ендоскопічні класифікації, прогнозування гістології, рецидив, колоректальна неоплазія.

Надійшла до редакції /
Received: 20.10.2025

Після доопрацювання /
Revised: 09.12.2025

Схвалено до друку /
Accepted: 24.12.2025

Конфлікт інтересів:
відсутній.

Conflicts of interest:
authors have no conflict
of interest to declare.

Colorectal laterally spreading tumors (LST) are a distinct form of non-polypoid colorectal neoplasia that extend laterally along the mucosal surface and often exceed 20 mm in diameter. Despite advances in optical imaging technologies, diagnostic accuracy for large LSTs varies widely among classification systems, emphasizing the need to assess combined endoscopic approaches and recurrence prediction models to improve risk stratification and treatment planning.

Aim. To compare the diagnostic accuracy of combinations of combined endoscopic classifications and recurrence prediction models to identify the most effective approach for granular and non-granular subtypes of laterally spreading tumors.

Materials and methods. A single-center mixed retrospective-prospective study was conducted at the Medical Educational and Scientific Center "University Clinic" (Zaporizhzhia), including 110 patients with LSTs ≥ 20 mm (2015–2024). Granular (LST-G) and non-granular (LST-NG) lesions were assessed using JNET, Kudo, Modified Sano, and Hiroshima classifications. Six combinations of endoscopic classification systems were tested in parallel to determine diagnostic metrics. The histological evaluation of the resected neoplasia served as the reference standard. Resection techniques included endoscopic mucosal resection (EMR), piecemeal EMR, endoscopic submucosal dissection (ESD), and hybrid ESD. Recurrence was assessed at 6 months, with its prediction evaluated using the SMSA, SERT, and Baylor College of Medicine (BCM) models.

Results. The JNET + Hiroshima combination showed the highest diagnostic performance (LST-G: 81.82 % (95 % CI, 67.29–91.81 %) sensitivity, 90.91 % (95 % CI, 70.84–98.88 %) specificity, 84.29 % (95 % CI, 72.76–92.30 %) diagnostic accuracy; LST-NG: 86.67 % (95 % CI, 59.54–98.34) sensitivity, 100 % (95 % CI, 86.28–100.00) specificity, 95.00 % (95 % CI, 83.08–99.39 % diagnostic accuracy). JNET + Kudo served as a strong alternative. Progressive histological changes and recurrence were significantly more common among LST-G (68.6 %) than LST-NG (37.5 %). Recurrences were observed only in the LST-G group (8/70). BCM score ≥ 1 demonstrated the highest predictive ability for recurrence (AUC: 0.78), outperforming SMSA and SERT models which demonstrated poor discrimination (AUC: 0.31–0.37).

Conclusions. The combination of JNET + Hiroshima or JNET + Kudo classifications optimizes histologic prediction in both granular and non-granular large LSTs. LST-Gs demonstrate a higher risk for advanced histology and recurrence. The BCM model is preferable for recurrence prediction in large granular LSTs.

Modern medical technology. 2026;18(1):5-11

Порівняльна ефективність комбінацій ендоскопічних класифікацій і моделей прогнозування рецидивів для великих пухлин товстої кишки, що поширюються латерально

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Пухлини товстої кишки, що поширюються латерально (LST), – окрема форма неполіпoidних колоректальних неоплазій, які поширюються латерально вздовж поверхні слизової оболонки і часто більші за 20 мм у діаметрі. Незважаючи на прогрес у технологіях візуалізації, діагностична точність для великих LST значно варіює залежно від використаної класифікаційної системи. Це обґрунтовує доцільність застосування комбінованих ендоскопічних підходів і моделей прогнозування рецидивів для покращення стратифікації ризику та планування лікування.

Мета роботи – порівняти діагностичну ефективність комбінацій ендоскопічних класифікацій і моделей прогнозування рецидивів для великих LST товстої кишки з окремим аналізом гранулярного і негранулярного підтипу.

Матеріали і методи. Одноцентрове змішане ретроспективно-проспективне дослідження здійснили в Навчально-науковому медичному центрі «Університетська клініка ЗДМФУ» (2015–2024), до дослідження залучено 110 пацієнтів із LST ≥ 20 мм. Гранулярні (LST-G) та негранулярні (LST-NG) ураження оцінювали

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за класифікаціями JNET, Kudo, Modified Sano та Hiroshima. Проведено паралельне тестування шести комбінацій ендоскопічних класифікацій з визначенням діагностичних метрик. Гістологічний висновок видаленої неоплазії використано як стандарт порівняння. Техніки резекції включали EMR, фрагментарну EMR, ESD та гібридну ESD. Через 6 місяців оцінювали наявність рецидиву, прогноз якого здійснено за допомогою моделей SMSA, SERT і Baylor College of Medicine (BCM).

Результати. Комбінація JNET і Hiroshima показала найвищу діагностичну ефективність (LST-G: чутливість – 81,82 % (95 % CI, 67,29–91,81 %), специфічність – 90,91 % (95 % CI, 70,84–98,88 %), діагностична точність – 84,29 % (95 % CI, 72,76–92,30 %); LST-NG: чутливість – 86,67 % (95 % CI, 59,54–98,34 %), специфічність – 100,00 % (95 % CI, 86,28–100 %), діагностична точність – 95,00 % (95 % CI, 83,08–99,39 %)). Комбінація JNET і Kudo стала хорошою альтернативою. Прогресивні гістологічні зміни виявляли значно частіше у LST-G (68,6 %) порівняно з LST-NG (37,5 %). Рецидиви зафіксовано лише у LST-G групі (8/70). Показник BCM ≥ 1 мав найвищу прогностичну здатність щодо рецидивів (AUC: 0,78), перевищуючи показники моделей SMSA та SERT, які мали низьку дискримінаційну здатність (AUC: 0,31–0,37).

Висновки. Комбінація класифікацій JNET і Hiroshima або JNET і Kudo оптимізує прогнозування гістологічних змін і для гранулярних, і для негранулярних великих LST. LST-G асоційовані зі значно вищим ризиком прогресивної гістології та рецидиву. Модель BCM є кращою для прогнозування рецидивів у великих гранулярних LST.

Сучасні медичні технології. 2026. Т. 18, № 1(68). С. 5-11

Recent global trends indicate that colorectal cancer poses a significant and growing public health challenge worldwide. In 2020, there were approximately 1.93 million new cases of colorectal cancer globally, with an age-standardized incidence rate of 19.5 per 100,000 individuals. The mortality burden is substantial, with around 935,000 deaths and an age-standardized mortality rate of 9 per 100,000 persons. Projections indicate the global burden of colorectal cancer is expected to increase by 60 % by 2030, reaching over 2.2 million new cases and 1.1 million deaths [1].

Colonoscopy remains the gold standard in colorectal cancer screening, primarily due to its dual ability to detect and remove benign precursor lesions, such as adenomatous polyps, before they progress to malignancy. Numerous studies demonstrate that colonoscopy screening reduces colorectal cancer incidence by approximately 30 % and mortality by about 32 % through the direct visualization and resection of early, non-invasive lesions. The procedure enables the identification of precancerous growth at a stage when treatment is most effective, thereby preventing the development of advanced disease and substantially improving patient outcomes [2].

Image-enhanced endoscopy [3] has revolutionized colorectal cancer diagnostics by enabling real-time, highly accurate prediction of histological changes in neoplastic lesions through enhanced visualization of mucosal and vascular patterns. This technique markedly surpasses conventional white-light endoscopy, particularly regarding the detection and characterization of subtle and flat lesions, using technologies such as narrow-band imaging (NBI), flexible spectral imaging color enhancement, blue laser imaging, and autofluorescence imaging. The adoption of standardized endoscopic classifications – including the Kudo [4], Modified Sano [5], Hiroshima [6], and Japan NBI Expert Team (JNET) [7] systems – is indispensable for this approach, as these frameworks facilitate the optical biopsy process by allowing endoscopists to reliably predict histopathology in vivo, optimize diagnostic precision, and standardize clinical decision-making [8].

Optical diagnosis has largely supplanted targeted forceps biopsy in the routine evaluation of colorectal lesions due to its high diagnostic accuracy and real-time histologic prediction

capabilities. Current evidence demonstrates that while forceps biopsy can still provide diagnostic information, it often fails to offer additional benefits over advanced optical classifications for most lesions prior to endoscopic resection, partly because biopsy samples may miss the most dysplastic or malignant areas not visible macroscopically. Consequently, targeted forceps biopsy is now primarily reserved for cases where deep invasive cancer is suspected, and endoscopic resection is not feasible, while optical diagnosis governs the assessment and management of the majority of colorectal neoplastic lesions. This shift enhances procedural efficiency, reduces patient risk, and streamlines clinical decision-making [9,10,11].

The JNET classification has demonstrated satisfactory accuracy in differentiating neoplastic from non-neoplastic colorectal lesions, with particularly high specificity for the detection of deeply invasive cancers (type 3). However, the classification's diagnostic performance in predicting histology shows limitations when applied to certain lesion subtypes, especially laterally spreading tumors (LST), with the granular mixed subtype being notably challenging. These lesions often present with extensive and irregular surface architecture, complicating endoscopic assessment and leading to reduced accuracy in histologic prediction within this subgroup [12,13].

In comparison, other classification systems, such as the Hiroshima and Modified Sano classifications, continue to provide detailed evaluations of vascular and pit patterns, often yielding even higher diagnostic metrics than JNET in certain contexts, particularly for lesions where surface and pit pattern analysis are more straightforward. These systems may incorporate more nuanced criteria, including pit pattern assessment through chromoendoscopy, which enhances the discrimination of invasive versus benign lesions in difficult cases [14].

Overall, while JNET provides a valuable framework for real-time optical diagnosis, especially when magnification and image-enhancement technologies are utilized, certain lesion types, like the granular mixed LST, still pose diagnostic challenges, warranting supplementary assessment tools such as pit pattern analysis to improve accuracy [12,15]. Although the JNET

classification represents a well-balanced and widely validated system for the optical diagnosis of colorectal lesions, it remains the most optimal rather than a perfect solution. Its strength lies in combining vascular and surface pattern assessment to guide histologic predictions, yet it faces diagnostic challenges, particularly with heterogeneous lesion types such as JNET type 2B, which includes a spectrum from high-grade intramucosal neoplasia to superficial submucosal invasive cancers [16]. These limitations necessitate adjunctive methods like pit pattern analysis for more accurate diagnosis in certain cases [17]. Accordingly, combining the JNET classification with other established systems such as the Hiroshima and Modified Sano classifications, which emphasize additional detailed vascular and pit pattern evaluations, has the potential to leverage the advantages of each. Such integrative approaches may enhance diagnostic precision and improve clinical decision-making in colorectal cancer management beyond what any single classification can achieve on its own.

Another unresolved issue is recurrence after removal of large LSTs, that remains a critical challenge in colorectal cancer management. The SMSA score [18], which incorporates lesion size, morphology, site, and access, has been a longstanding model for predicting recurrence risk. However, recent years have seen the development of additional predictive tools, including the Sydney EMR Recurrence Tool (SERT) [19] and the Baylor College of Medicine (BCM) model [20], which aim to improve risk stratification particularly after piecemeal endoscopic mucosal resection (pEMR), but can potentially be used after other methods of endoscopic removal. Combining insights from these models could optimize the clinical algorithm for managing large LSTs, potentially reducing recurrence rates and improving patient outcomes.

Aim

The aim of this study is to compare the diagnostic accuracy of combined endoscopic classifications and recurrence prediction models to identify the most effective approach for granular and non-granular subtypes of laterally spreading tumors.

Materials and methods

This study was conducted at the Medical Educational and Scientific Center "University Clinic" (Zaporizhzhia) as a single-center investigation. Patient data were retrospectively collected between 2015 and 2022 and prospectively enrolled from 2023 to 2024. The study cohort comprised 110 patients diagnosed with laterally spreading tumors (LSTs) measuring greater than 20 mm in diameter. For each participant, only the largest lesion was included for analysis.

Inclusion criteria encompassed individuals aged 18 years or older presenting with LSTs that satisfied the specified size threshold. Key exclusion criteria were defined as: age under 18 years; endoscopic features suggestive of deep tumor invasion; coexistence of malignant neoplasms at other anatomical sites; or contraindications to LST excision.

Patients were classified according to the Paris system described by Se Kudo et al. [21], based on macroscopic lesion morphology. The case series was stratified into two major groups:

the granular LST (LST-G, $n = 70$) and the non-granular LST (LST-NG, $n = 40$).

Eligible lesions were assessed by an experienced endoscopist utilizing both virtual and vital chromoendoscopy with indigo-carmin. Vascular and pit patterns were evaluated in accordance with the criteria established by the Kudo [4], JNET [7], Modified Sano [5], and Hiroshima [6] classifications. Following comprehensive optical evaluation, lesions meeting resection criteria were excised endoscopically, and histopathological examination of the specimen was considered the diagnostic gold standard.

All neoplastic lesions were removed through endoscopic techniques. Resection modality was selected based on lesion size and morphological characteristics: endoscopic mucosal resection (EMR) in 29 cases (26.36 %, en bloc removal), piecemeal EMR (pEMR) in 45 cases (40.91 %), endoscopic submucosal dissection (ESD) in 25 cases (22.73 %), and hybrid ESD in 11 cases (10 %).

In accordance with current post-polypectomy surveillance recommendations [22] and tumor size considerations, all patients underwent follow-up colonoscopy at 6 months post-resection. Recurrence was defined as the detection of adenomatous tissue at the excision scar site consistent with the original tumor's morphology.

Categorical variables, including histopathological findings and resection methods, were summarized as percentages. Lesion size was reported as mean with standard deviation. For each group, six combinations of endoscopic classification systems were examined: JNET + Hiroshima, JNET + Kudo, JNET + Modified Sano, Hiroshima + Kudo, Modified Sano + Kudo, and Modified Sano + Hiroshima. For each pair of classifications, a combined test was considered positive if at least one of the two classifications indicated a positive result (parallel testing). True-positive, false-negative, false-positive, and true-negative values were calculated to derive sensitivity, specificity, negative predictive value (NPV), positive predictive value (PPV) and diagnostic accuracy metrics. Confidence intervals (95 % CI) for these proportions were computed using the Wilson Score Interval. Fisher's exact test was applied to 2×2 contingency tables to calculate p-values. The significance level was set at $p < 0.05$.

Tumor recurrence was scored as a binary outcome (0 or 1), and recurrence prediction model scores (SMSA, SERT, BCM) were assigned following respective primary literature: SMSA score range 4–17 [18], SERT range 0–4 [19], BCM range 0–4 [20]. Logistic regression was used to evaluate relationships between recurrence model scores and complication outcomes. The discriminatory power of each model was further evaluated using receiver operating characteristic (ROC) analysis with calculation of the area under the curve (AUC) and cutoff values determined by Youden's J statistics.

Statistical analyses were performed using Statistica 13 (Stat-Soft Inc., Tulsa, OK, USA; License No. JPZ804I382130ARCN10-J).

Results

In the LST-G group, the mean lesion size was 38.79 ± 16.88 mm, which was substantially larger than that observed in the LST-NG group (23.75 ± 6.38 mm). Tubulo-villous

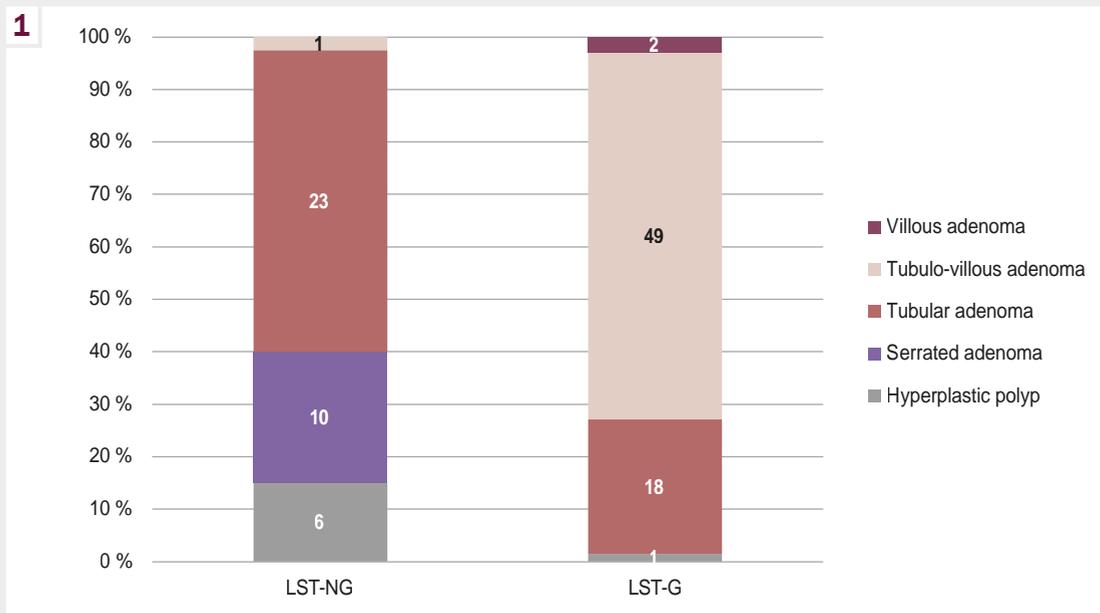


Fig. 1. Distribution of morphological subtypes in granular and non-granular LST groups.

adenomas constituted the majority of resected lesions in the LST-G group (49 out of 70 cases), whereas tubular adenomas were most prevalent in the LST-NG group (23 out of 40 cases). A comprehensive overview of the morphological subtype distribution across both groups is illustrated in Fig. 1.

Table 1 presents a comparative analysis of combinations of endoscopic classifications in the LST-G group. The JNET + Hiroshima combination achieved the highest diagnostic accuracy (84.29%), with a sensitivity of 81.82% and specificity of 90.91%, representing the most effective balance between lesion detection and minimization of false positives. This superiority is further supported by its diagnostic accuracy index (84.29%) and Youden's J statistic (0.7273).

The JNET + Kudo pairing ranked second, yielding a Youden's J statistic of 0.6136 and diagnostic accuracy of 78.57%, with slightly reduced sensitivity (75%) and specificity (86.36%) relative to the JNET + Hiroshima combination.

Combinations incorporating the Modified Sano classification, such as JNET + Modified Sano, Modified Sano + Kudo, and Modified Sano + Hiroshima, demonstrated high sensitivity (range: 93.18–95.45%) but notably lower specificity (40.91–45.45%). This reduced specificity may result in an excessive number of false positives, which may be undesirable in clinical practice.

The Kudo + Hiroshima combination exhibited the lowest sensitivity (56.82%) and diagnostic accuracy (70%), indicating limited reliability for optical assessment and histological prediction of large granular LSTs.

As demonstrated in Table 2, for the non-granular LST group, the combination of JNET + Hiroshima proved to be the most effective, achieving the highest specificity (100%), diagnostic accuracy (95%), positive predictive value (100%), and Youden's index (0.8667). Although its sensitivity (86.67%) and negative predictive value (92.59%) were marginally lower compared to other combinations, these metrics remained robust.

JNET + Kudo and JNET + Modified Sano were the second-best performing combinations, each yielding a high Youden's index (0.8533), diagnostic accuracy (92.50%), and the highest sensitivity (93.33%) and negative predictive value (95.83%).

The Modified Sano + Kudo pairing exhibited sensitivity equivalent to that of the leading combination but demonstrated inferior specificity, diagnostic accuracy, and predictive values.

Among all combinations evaluated, Hiroshima + Kudo and Modified Sano + Hiroshima had the lowest sensitivity (73.33%) and were consistently outperformed by the JNET + Hiroshima combination across all diagnostic metrics.

Progressive histological changes (high-grade dysplasia and/or cancer in situ) were observed in 37.5% (15/40) of patients in the LST-NG group and in 68.6% (48/70) of those in the LST-G group. The difference between the two groups was statistically significant ($p = 0.0025$). These findings indicate a higher frequency of advanced histological alterations in LST-G lesions compared with LST-NG lesions.

According to follow-up data, no recurrences were observed in the non-granular LST group; consequently, recurrence was not predicted and all subsequent analyses of recurrence were limited to the LST-G group.

Among granular LSTs, local recurrence at the post-resection scar site occurred in 8 out of 70 patients. Statistical evaluation indicated that the BCM scoring system demonstrated the highest predictive performance for recurrence, with an area under the curve (AUC) of 0.78 (95% CI, 0.63–0.91). Using a threshold of 1 point, the BCM model achieved a sensitivity of 66.67% (95% CI, 54.11–100) and a specificity of 80.6% (95% CI, 70.13–88.89).

The SERT scale and the SMSA scoring system demonstrated areas under the curve (AUC) of 0.37 (95% CI, 0.19–0.63) and 0.31 (95% CI, 0.08–0.63), respectively. These results indicate that both models perform no better than chance in predicting recurrence in large granular LSTs.

Table 1. Comparison of combinations of endoscopic classifications in the LST-G group

Classifications	Sensitivity (95 % CI)	Specificity (95 % CI)	NPV (95 % CI)	PPV (95 % CI)	Diagnostic accuracy (95 % CI)	Youden's J statistic	p-value
JNET + Hiroshima	81.82 % (67.29–91.81)	90.91 % (70.84–98.88)	71.43 % (51.29–86.82)	94.74 % (82.25–99.36)	84.29 % (72.76–92.30)	0.7273	<0.0001
JNET + Kudo	75.00 % (60.55–86.02)	86.36 % (65.09–97.09)	65.52 % (45.67–82.06)	90.91 % (77.01–97.88)	78.57 % (66.31–87.97)	0.6136	<0.0001
JNET + Modified Sano	95.45 % (84.53–99.44)	40.91 % (21.71–62.33)	81.82 % (48.22–97.72)	73.68 % (59.99–84.70)	75.71 % (63.38–85.57)	0.3636	<0.0001
Hiroshima + Kudo	56.82 % (41.24–71.51)	92.31 % (74.87–99.05)	55.56 % (38.10–72.06)	92.59 % (75.71–99.09)	70.00 % (57.18–80.87)	0.4913	<0.0001
Modified Sano + Kudo	93.18 % (81.34–98.57)	42.31 % (23.37–62.96)	78.57 % (49.20–95.34)	73.21 % (59.02–84.70)	74.29 % (61.93–84.43)	0.3549	<0.0001
Modified Sano + Hiroshima	93.18 % (81.34–98.57)	45.45 % (25.16–66.29)	78.57 % (49.20–95.34)	74.55 % (60.40–85.71)	75.71 % (63.38–85.57)	0.3863	<0.0001

Table 2. Comparison of combinations of endoscopic classifications in the LST-NG group

Classifications	Sensitivity (95 % CI)	Specificity (95 % CI)	NPV (95 % CI)	PPV (95 % CI)	Diagnostic accuracy (95 % CI)	Youden's J statistic	p-value
JNET + Hiroshima	86.67 % (59.54–98.34)	100.00 % (86.28–100.00)	92.59 % (75.71–99.09)	100.00 % (75.29–100.00)	95.00 % (83.08–99.39)	0.8667	<0.0001
JNET + Kudo	93.33 % (68.05–99.83)	92.00 % (73.97–99.02)	95.83 % (78.88–99.89)	87.50 % (61.65–98.45)	92.50 % (79.61–98.43)	0.8533	<0.0001
JNET + Modified Sano	93.33 % (68.05–99.83)	92.00 % (73.97–99.02)	95.83 % (78.88–99.89)	87.50 % (61.65–98.45)	92.50 % (79.61–98.43)	0.8533	<0.0001
Hiroshima + Kudo	73.33 % (44.90–92.21)	92.00 % (73.97–99.02)	85.19 % (66.27–95.81)	84.62 % (54.55–98.08)	85.00 % (70.16–94.29)	0.6533	<0.0001
Modified Sano + Kudo	86.67 % (59.54–98.34)	84.00 % (63.92–95.46)	91.30 % (71.96–98.93)	76.47 % (50.10–93.19)	85.00 % (70.16–94.29)	0.7067	<0.0001
Modified Sano + Hiroshima	73.33 % (44.90–92.21)	92.00 % (73.97–99.02)	85.19 % (66.27–95.81)	84.62 % (54.55–98.08)	85.00 % (70.16–94.29)	0.6533	<0.0001

Discussion

The results of our study highlight that identical endoscopic diagnostic approaches can produce divergent outcomes depending on the LST subtype. Specifically, endoscopic classifications tend to yield higher diagnostic accuracy metrics in non-granular LSTs compared to granular types. This discrepancy is likely attributable to the greater ease of visualizing the flat, smooth surface characteristic of non-granular lesions, whereas the nodular, irregular morphology of granular LSTs presents challenges. The latter often features thick, opaque mucus production – a hallmark of tubulovillous adenomas, which comprise the majority of granular LSTs – further complicating optical assessment and possibly obscuring diagnostic features, as it was also described before [8,17].

The diagnostic sensitivity and specificity achieved in our investigation for combinations such as JNET + Hiroshima and JNET + Kudo (sensitivity: 75.00–93.33 %, specificity: 86.36–100.00 %) for large laterally spreading tumors notably surpass

the performance of individual endoscopic classifications reported in recent literature.

For the JNET classification, contemporary studies report a sensitivity of 56.6 % for high-grade colorectal lesions and a specificity ranging between 77.4 % and 95.7 %, with notable variability depending on lesion subtype and size. While some series demonstrate correctly classified rates above 77 %, overall discriminatory ability for histological prediction remains moderate in challenging cases [12,13,14].

The Kudo classification remains one of the most widely utilized and recommended systems for determining the morphological type of colorectal neoplasms. While it performs effectively in identifying invasive cancer and in differentiating neoplastic from non-neoplastic polyps, its ability to distinguish benign lesions from dysplasia and early-stage cancer is limited, aligning with previous reports [23,24].

Recent research has also explored multimodal classification approaches to enhance diagnostic accuracy.

The supplementary application of the Kudo pit pattern in conjunction with the JNET classification has been proposed to mitigate limitations in JNET's performance, particularly for type 2B lesions, by refining diagnostic granularity. This combined approach has shown promise for enhancing detection of high-grade dysplasia and invasive cancer, supporting the need for integrated diagnostic strategies [13].

The novel Colorectal Neoplasia Endoscopic Classification to Choose the Treatment (CONECCT) integrates visual and macroscopic features to predict morphologic type of neoplasia and submucosal or deep invasion in colorectal lesions [25]. Based on the most recent evidence, the CONECCT classification demonstrates high sensitivity, ranging from 70.7 % to 100.0 % across different studies, but frequently at the expense of low specificity (as low as 26.2 %) and positive predictive value (11.6 %) for submucosal cancer prediction in colorectal lesions. In other contexts, particularly in heterogeneous cohorts and for specific lesion subtypes, the CONECCT classification has reported more balanced specificity values between 83.4 % and 98.9 %. Thus, its diagnostic performance varies depending on lesion characteristics, with a notable tradeoff between sensitivity and specificity depending on the clinical scenario and population studied. However, it is important to note that these diagnostic metrics were primarily reported in studies evaluating heterogeneous lesion cohorts, rather than focusing specifically on large colorectal lesions [25,26,27].

Overall, these findings are consistent with contemporary literature emphasizing the benefits and limitations of individual and combined endoscopic classifications. They underscore the importance of tailored diagnostic approaches contingent upon lesion subtype morphology and highlight the ongoing evolution of endoscopic optical diagnosis in colorectal neoplasia management.

The SMSA scoring system has previously been evaluated as a model for recurrence prediction and has consistently demonstrated mediocre results. The SERT and BCM models were specifically developed to predict recurrence after piecemeal EMR procedures, but in our study, both were applied to a mixed cohort of patients who had undergone various endoscopic resection methods, including piecemeal EMR, en bloc EMR, ESD, and hybrid ESD. Despite the marked lack of predictive power observed with the SMSA and SERT models – rendering them ineffective in this clinical context, the BCM model exhibited fair discriminative ability. Accordingly, the BCM model was validated in our analysis as an effective tool for predicting recurrence in large granular LSTs regardless of the method of endoscopic removal used. These findings are consistent with broader recent literature, which highlights the superiority and reliability of the BCM model over alternative systems for risk stratification and recurrence prediction in colorectal neoplasia [19,20,28].

Conclusions

1. The combination of JNET and Hiroshima classifications was identified as the most effective and accurate for predicting histological changes in both granular and non-granular large

laterally spreading tumors, with JNET and Kudo serving as a viable alternative.

2. Large granular LSTs exhibit a higher incidence of progressive histological changes and tumor recurrence compared to non-granular types.

3. The Baylor College of Medicine model demonstrated good predictive performance for recurrence, achieving an area under the curve (AUC) of 0.78. ABCM score of 1 or greater significantly correlates with an increased risk of recurrence.

Prospects for further scientific research. Future research should focus on expanding and validating combined endoscopic classification systems in multicenter and international cohorts, thus ensuring generalizability and reproducibility across diverse patient populations. Further studies should also prioritize the longitudinal assessment of BCM and emerging recurrence prediction models to refine postoperative surveillance protocols and optimize individualized management strategies. Investigations into molecular markers and genetic profiles associated with recurrence and progression in LSTs could provide complementary predictive tools, fostering a more comprehensive, precision-medicine approach to colorectal neoplasia.

Ethical approval

All procedures performed in this study were in accordance with the ethical standards of the institutional research committee and Helsinki declaration and its later amendments. Informed consent was obtained from all participants included in the study. The Bioethics Committee of Zaporizhzhia State Medical and Pharmaceutical University reviewed the materials presented in the article and confirmed their compliance with all moral and ethical standards stipulated by the current regulatory and legal documents (Protocol No. 10 dated September 18, 2025).

Funding

The study was performed without financial support.

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