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Lesion-Based Comparison of Storz Professional Image Enhancement System and White-Light Cystoscopy for Detecting Bladder Carcinoma In Situ

Mesane Karsinoma İn Situ Tanısında Storz Professional Image Enhancement System ile Beyaz Işık Sistoskopisinin Lezyon Bazlı Karşılaştırılması

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ABSTRACT

Objective: This study aimed to evaluate whether the Storz Professional Image Enhancement System (SPIES) offers superior diagnostic accuracy compared with white-light cystoscopy (WLC) in the detection of bladder carcinoma in situ (CIS), given the limited evidence available for CIS-suspicious lesions.

Material and Methods: This retrospective study included 46 patients who underwent cystoscopy under local anesthesia for microscopic or macroscopic hematuria between July 2022 and July 2025. Patients with prior cystoscopy, pelvic radiotherapy, or active urinary tract infection were excluded. CIS-suspicious lesions identified during WLC prompted scheduling for TUR-BT under general anesthesia. During TUR-BT, all lesions were evaluated sequentially with WLC followed by three SPIES modes (Clara+Chroma, Spectra A, and Spectra B) by a single experienced urologist. A total of 95 CIS-suspicious lesions were recorded, individually resected, and submitted for separate pathological analysis.

Results: A total of 95 CIS-suspicious lesions were identified in 46 patients, of which 28 were CIS-positive. Lesion-based diagnostic accuracy was 30.5% for WLC and 33.7% for SPIES. SPIES detected 23 additional lesions not visualized with WLC, corresponding to an incremental lesion detection contribution of 24.2% overall and 31.9% relative to WLC-positive findings. Among CIS-positive lesions, SPIES provided an incremental diagnostic gain of 35.7% and a 55.6% relative improvement over WLC. McNemar's test demonstrated a statistically significant difference in paired detection outcomes between the modalities ($\chi^2 = 8.1$, $p = 0.004$), confirming the superior detection performance of SPIES.

Conclusions: SPIES outperformed WLC in detecting bladder CIS, indicating a meaningful diagnostic benefit that warrants validation in prospective comparative studies.

Keywords: bladder, carcinoma in situ, cystoscopy

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ÖZET

Amaç: Bu çalışma ile Storz Professional Image Enhancement System (SPIES) yönteminin mesane karsinoma in situ (CIS) tespitinde beyaz ışık sistoskopiye (WLC) kıyasla üstün tanısal doğruluk sağlayıp sağlamadığının değerlendirilmesi amaçlandı.

Gereç ve Yöntemler: Bu retrospektif çalışmaya, Temmuz 2022 ile Temmuz 2025 arasında mikroskopik veya makroskopik hematüri nedeniyle lokal anestezi altında sistoskopi yapılan toplam 46 hasta dahil edildi. Daha önce sistoskopi öyküsü bulunanlar, pelvik radyoterapi geçmişi olanlar ve aktif üriner sistem enfeksiyonu bulguları taşıyan hastalar dışlandı. WLC sırasında CIS şüphesi oluşturan lezyonlar tespit edildiğinde hastalar genel anestezi altında TUR-BT için planlandı. TUR-BT sırasında tüm lezyonlar sırasıyla WLC ve ardından üç SPIES modu (Clara+Chroma, Spectra A ve Spectra B) ile değerlendirildi. Toplam 95 CIS-şüpheli lezyon kaydedildi; her biri ayrı olarak rezeke edilerek patolojik incelemeye gönderildi.

Bulgular: Çalışmada 46 hastada toplam 95 CIS-şüpheli lezyon belirlendi ve bunların 28'i CIS-pozitifti. Lezyon bazlı tanısal doğruluk WLC için %30,5, SPIES için %33,7 olarak bulundu. SPIES, WLC ile görüntülenemeyen 23 ek lezyonu saptadı; bu durum tüm lezyonlar içinde %24,2'lik ve WLC-pozitif lezyonlara göre %31,9'luk artırılmış lezyon tespit katkısına karşılık gelmekteydi. CIS-pozitif lezyonlar arasında SPIES, WLC'nin kaçırdığı 10 lezyonu ek olarak tespit ederek %35,7'lik artırılmış tanısal kazanç ve WLC'ye göre %55,6'lık göreceli tanısal iyileşme sağladı. McNemar testi, iki yöntem arasında eşleştirilmiş tespit sonuçları bakımından anlamlı fark olduğunu gösterdi ($\chi^2 = 8.1$, $p = 0.004$) ve SPIES'in üstün tespit performansını destekledi.

Sonuç: SPIES, mesane CIS tespitinde WLC'ye kıyasla daha üstün performans göstermiş olup, klinik açıdan anlamlı bir tanısal avantaj sunduğu düşünülmektedir. Bu etkinin daha net ortaya konulması için ileri görüntüleme yöntemlerini içeren prospektif karşılaştırmalı çalışmalar gereklidir.

Anahtar Kelimeler: karsinoma in situ, mesane, sistoskopi

INTRODUCTION

Carcinoma in situ (CIS) is a high-grade, non-invasive urothelial tumor that is confined to the epithelium and demonstrates distinct macroscopic and microscopic features compared with papillary bladder tumors. CIS may occur alone or in conjunction with papillary lesions and can also be detected in the upper urinary tract and urethra. Its appearance under white-light cystoscopy (WLC) often mimics benign conditions such as inflammation, catheter-related hyperemia, and post-intravesical treatment changes, making accurate differentiation from these lesions particularly challenging (1).

Numerous studies have investigated whether advanced imaging modalities offer superior diagnostic performance compared with WLC in the detection of bladder tumors, including the challenging subgroup of CIS lesions. In the study by Pederzoli et al., which evaluated 135 bladder biopsies from 79 patients, CIS detection rates under WLC and blue-light cystoscopy (BLC) were compared; notably, 23 of the 41 CIS lesions (56%) were not visible on WLC and were identified only with BLC (2). Similarly, in the cohort of 139 patients assessed by Geavlete et al., narrow-band imaging (NBI) demonstrated significantly higher lesion-based CIS detection rates compared with WLC (93.75% vs. 71.90%) (3). In a multicenter study by Drejer et al., including 482 biopsies, sensitivity analyses performed on each biopsy revealed that both BLC and NBI provided markedly higher sensitivity than WLC (NBI 72.7% and BLC 78.2% vs. WLC 52.7%; $p<0.05$) (4). Collectively, these findings indicate that WLC alone may be insufficient for reliable CIS detection and highlight the clinical importance of incorporating enhanced imaging modalities to improve diagnostic sensitivity.

Although several studies have evaluated the effectiveness of the SPIES (Storz Professional Image Enhancement System) system in the diagnosis and follow-up of bladder tumors, research focusing exclusively on CIS cases remains limited. This study aims to determine whether SPIES provides superior diagnostic performance compared with WLC in the detection of bladder CIS.

MATERIALS AND METHODS

This study was approved by the Institutional Review Board of Bağcılar Training and Research Hospital (Approval Number: 2025/11/05/105, Date: 2025-11-28). Between July 2022 and July 2025, a total of 46 patients over the age of 18 who underwent cystoscopy under local anesthesia for microscopic or macroscopic hematuria at Bağcılar Training and Research Hospital were retrospectively included. Patients with a prior history of cystoscopy for any indication, a history of pelvic radiotherapy, or clinical findings suggestive of an active urinary tract infection were excluded. Demographic and clinical variables, including age, sex, type of hematuria at presentation (microscopic or macroscopic), and whether transurethral resection of bladder tumor (TUR-BT) was subsequently performed under spinal or general anesthesia, were recorded. When CIS-suspicious lesions were identified during cystoscopy performed under local anesthesia using WLC, the patients were scheduled for TUR-BT under general anesthesia.

All cystoscopic evaluations and transurethral resections during TUR-BT were performed by a single experienced urologist (IU). Before resection, a detailed cystoscopic examination was first carried out using WLC, and all CIS-suspicious lesions were recorded. The bladder was then re-examined using three SPIES modalities (Clara+Chroma, Spectra A, and Spectra B). During this evaluation, additional suspicious lesions not detected with WLC were identified, and lesions initially considered suspicious under WLC but assessed as benign with SPIES were also documented (Figure 1). When evaluated separately with WLC and SPIES, a total of 95 CIS-suspicious lesions were identified in 46 patients. Each lesion was subsequently resected individually with bipolar energy under the Clara+Chroma mode, and all specimens were submitted separately for pathological analysis according to their endoscopic descriptions. All histopathological assessments were performed by a single pathologist specialized in urologic pathology.

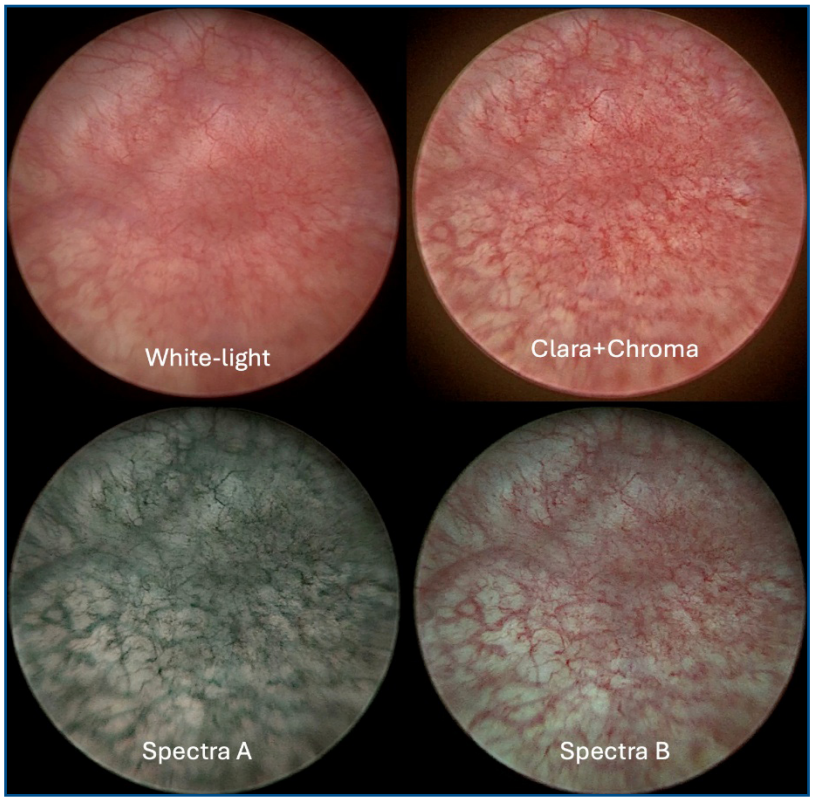

Figure 1. Representative images of a CIS-suspicious lesion obtained with WLC, Clara+Chroma, Spectra A, and Spectra B modalities.

Statistical Analysis

The primary outcome of the study was the detection of additional CIS-positive lesions by the two imaging modalities. Descriptive statistics were presented as frequencies, percentages, means, and standard deviations. Comparisons of clinical and operative characteristics between groups were performed using the independent samples t-test and Fisher's exact test. The efficacy of the diagnostic modalities was evaluated using sensitivity and accuracy measures. McNemar's test was applied to compare paired diagnostic detection outcomes between WLC and SPIES. A p-value of <0.05 was considered statistically significant for all analyses. All statistical analyses were performed using IBM SPSS Statistics for Windows, version 29.0 (IBM Corp., Armonk, NY, USA).

RESULTS

The mean age of the patients was 67.6±4.4 years. There were no statistically significant differences between the CIS-positive and CIS-negative groups with respect to age, sex, type of hematuria, anesthesia method, or lesion multiplicity (Table 1). Among the 46 patients included in the study, at least one CIS-positive lesion was identified in 19 patients, and CIS positivity was confirmed in 28 of the 95 lesions evaluated. WLC detected 18 of the 28 CIS-positive lesions, whereas SPIES did not miss any CIS-positive lesions. Consequently, on a lesion-based analysis, the sensitivity was 60.7% for WLC and 100% for SPIES, and the diagnostic accuracy rates were 30.5% and 33.7%, respectively (Table 2).

Using a paired lesion-based analysis, SPIES demonstrated a significantly higher detection rate compared with WLC. In the concordance assessment, SPIES detected 23 additional lesions that were not identified by WLC, corresponding to an incremental lesion detection contribution of 24.2% of all lesions and 31.9% relative to WLC-positive findings. Among the 28 CIS-positive lesions, SPIES detected all lesions, whereas WLC missed 10 of them. This represents an incremental CIS diagnostic gain of 35.7% and a 55.6% relative improvement over the CIS-positive lesions identified by WLC. McNemar's test demonstrated a statistically significant difference in paired detection outcomes between the two modalities ($\chi^2 = 8.1$, $p = 0.004$), indicating that SPIES provides a markedly higher diagnostic yield for detecting CIS-positive lesions.

Table 1. Comparison of patient characteristics according to CIS status

	CIS-negative	CIS-positive	p-value
Age, mean±SD	68.29±4.00	66.63±4.85	0.105
Gender, n (%) Male Female	 22 (81.5) 5 (18.5)	 17 (89.5) 2 (10.5)	 0.552
Hematuria, n (%) Microscopic Macroscopic	 15 (55.6) 12 (44.4)	 13 (68.4) 6 (31.6)	 0.379
Anesthesia, n (%) Spinal General	 19 (70.4) 8 (29.6)	 14 (73.7) 5 (26.3)	 0.806
Number of lesions, n (%) Single Multiple	 12 (44.4) 15 (55.6)	 4 (21.1) 15 (78.9)	 0.101

CIS: carcinoma in situ, SD: standard deviation.

Table 2. Distribution of CIS-suspicious lesions by WLC and SPIES findings

	CIS-negative	CIS-positive	Total	p-value
WLC-positive/SPIES-positive	51	18	69	0.004*
WLC-negative/SPIES-positive	12	10	22	
WLC-positive/SPIES-negative	4	0	4	

* McNemar's test. CIS: carcinoma in situ, WLC: white-light cystoscopy, SPIES: Storz Professional Image Enhancement System

DISCUSSION

The SPIES platform offers four enhancement modes designed to improve image quality without the use of intravesical contrast agents. Chroma enhances image sharpness, whereas Clara increases the visibility of darker regions, and their combined application provides clearer and more detailed endoscopic views. Spectra A and Spectra B modify the spectral response of the system, thereby improving color contrast and potentially facilitating the detection of subtle mucosal abnormalities (5). In a study by Kamphuis et al. involving 73 participants, 20 bladder lesions were evaluated using four imaging modalities (WLC, Clara+Chroma, Spectra A, and Spectra B), and Clara+Chroma, Spectra A, and Spectra B consistently demonstrated statistically significant superiority over WLC in terms of image quality, although no significant differences were observed in delineation time (6). Similarly, in a web-based survey by Mulawkar et al., including 273 observers who assessed suspicious lesions from 16 patients, both Spectra A and Spectra B significantly improved the diagnostic accuracy of WLC ($p<0.001$) (7).

Several studies have demonstrated that performing TUR-BT under SPIES guidance enhances diagnostic accuracy in bladder cancer. In a study by Howard et al. involving 49 patients with 165 lesions, the Chroma mode was compared with WLC and yielded an additional malignancy detection rate of 36% across both low-grade and high-grade tumors (8). In another study, Gnyawali et al. compared Spectra A with WLC in 64 patients with 193 lesions; the false-positive rates of TUR-BT performed under Spectra A and WLC guidance were 21.19% and 15.86% ($p = 0.006$), while the false-negative rates were 4% and 19.2% ($p = 0.001$), respectively (9). Beyond diagnostic performance, some studies have focused on comparing recurrence rates in patients undergoing TUR-BT with SPIES versus WLC. In a prospective randomized study by Trelles Guzmán et al. involving 103 patients, recurrence outcomes were assessed over a median follow-up of 12 months. The overall recurrence rates in the SPIES and WLC groups were 12.2% and 25.9%, respectively, with a statistically significant difference in the low- and intermediate-risk subgroup (7.7% vs. 30.8%, $p = 0.003$) (10). Similarly, in a multicenter prospective study conducted by de la Rosette et al., including 689 patients with 18 months of follow-up, recurrence rates differed significantly between the two modalities in the primary low- and intermediate-risk subgroup (31.9% vs. 22.3%, $p = 0.035$), whereas no significant differences were identified between the groups in the remaining risk categories (11).

In our study, SPIES outperformed WLC in the diagnosis of bladder CIS by identifying 10 additional CIS-positive lesions that were missed by WLC. This enhanced detection capability, reflected by higher sensitivity, greater lesion-based diagnostic accuracy, and a statistically significant difference in paired detection outcomes on McNemar's analysis, suggests that SPIES may provide a clinically meaningful advantage in the endoscopic evaluation of patients at risk for CIS. The most prominent limitations of the study include the lack of assessment of the impact of SPIES use on operative time, the absence of lesion classification based on their intravesical location, and the lack of a comparative analysis with simultaneous cytological evaluation. However, to the best of our knowledge, our study holds particular significance as it is the first to perform a comparative evaluation specifically in CIS-suspicious lesions rather than within a predefined subgroup.

CONCLUSIONS

SPIES markedly improved the endoscopic detection of CIS, identifying additional CIS-positive lesions that were missed by WLC. Its superior sensitivity, diagnostic accuracy, and the statistically significant difference in paired detection outcomes indicate a meaningful clinical advantage in evaluating patients at risk for bladder CIS. To better delineate the magnitude of this benefit, prospective comparative studies incorporating other advanced imaging modalities such as NBI and BLC are warranted.

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Informed Consent: Informed consent was obtained from all individual participants included in the study.

Data Availability: All data generated or analyzed during this study are included in this article. Further inquiries can be directed to the corresponding author.

Author Contributions: IU: Concept and design, data collection, data analysis and interpretation, manuscript writing, statistical analysis. YED: Concept and design, data collection, data analysis and interpretation. AYM: Critical revision of the manuscript, supervision. All authors read and approved the final manuscript.

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