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Diagnostic accuracy of optical coherence tomography for bladder cancer: A systematic review and meta-analysis

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ABSTRACT

Background: Bladder cancer is the fourth most common malignancy in men and a considerable disease burden globally. Multiple studies have focused on the accuracy of optical coherence tomography for bladder cancer diagnosis; however, the findings are inconsistent. Here, we assessed the accuracy of optical coherence tomography for bladder cancer diagnosis.
Methods: Embase, PubMed, Medline, Web of Science, and the Cochrane Library database were searched for relevant studies from the earliest date available through March 11, 2019. Studies evaluating the accuracy of optical coherence tomography bladder cancer diagnosis were included. Pooled sensitivity, specificity, and area under the curve values of weighted symmetric summary receiver operating curves, were calculated at the per-lesion level.
Results: Eleven studies, with a total of 1933 lesions, were included in the final analysis. The pooled results indicated that optical coherence tomography can differentiate bladder cancer from benign lesions: sensitivity, 94.9% (95% confidence interval: 92.7%–96.6%); specificity, 84.6% (95% confidence interval: 82.6%–86.4%); area under the curve, 0.97. Moreover, compared with optical coherence tomography alone, combined optical coherence tomography and fluorescence cystoscopy increased the diagnostic accuracy (sensitivity, 94.3% *vs.* 87.3%; specificity, 89.2% *vs.* 73.9%). Cross-polarization optical coherence tomography could also distinguish bladder cancer from normal tissue: sensitivity, 92.0% (95% confidence interval: 87.0%–95.6%); specificity, 84.4% (95% confidence interval: 81.7%–86.9%); area under the curve, 0.95.
Conclusions: Optical coherence tomography can accurately differentiate malignant from benign bladder lesions, particularly when combined with fluorescence cystoscopy.

1. Introduction

Bladder cancer is the fourth most common malignancy in men, with 79,030 new cases and 16,870 deaths expected in 2017 in the United States [1]. Approximately 80% of diagnosed bladder tumors are non-muscle invasive bladder cancer, at stages Ta, T1, and Tis [2]. Due to the high recurrence rate and the long-term follow-up required, the treatment cost for non-muscle invasive bladder cancer represents a considerable disease burden [3]. White light cystoscopy with transurethral resection of all visible tumors is the standard tool for the diagnosis, staging, and treatment of bladder cancer [4]; however, white light cystoscopy has several well-recognized limitations. First, non-papillary bladder cancer, such as carcinoma in situ, can easily be missed [5]. Second, no information regarding histopathologic diagnosis is obtained during cystoscopy, which may lead to incomplete resection of bladder tumors. In addition, it is difficult to accurately estimate the stage of a bladder tumor using white light cystoscopy, even for an experienced urologist [6]. These limitations of white light cystoscopy contribute to the high risk of cancer persistence and high recurrence rate of bladder cancer [7].

To date, several technologies have emerged with the goal of improving bladder cancer detection [8], including fluorescence cystoscopy [9], narrow-band imaging [10,11], confocal laser endomicroscopy [12,13], and optical coherence tomography. Among these technologies, optical coherence tomography has been validated to improve bladder cancer detection by providing high resolution, real-time,

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subsurface imaging of biological tissue. The principle of optical coherence tomography is analogous to B-mode ultrasonography, except that light is used, rather than sound. Using near infrared light and the unique backscattering pattern of specific tissue characteristics, optical coherence tomography enables the detection of microarchitectural features to a resolution of 10–20 μm [14]. Further, with a penetration depth of 1–2 mm, optical coherence tomography can distinguish structural changes in the bladder wall involving the mucosa, lamina propria, and superficial muscularis propria [15]. To date, multiple studies have focused on evaluating the accuracy of optical coherence tomography for bladder cancer diagnosis, with a variety of findings [16–26]. Manyak et al. [21] reported that optical coherence tomography had sensitivity of 100% and specificity of 89% for diagnosis of bladder cancer, compared with histological examination of targeted biopsies; however, this high accuracy has not been verified in other studies [17,25]. In a study of 116 patients, Gladkova et al. [17] reported the sensitivity and specificity of optical coherence tomography for diagnosis of flat malignant bladder lesions was 81.2% and 70.0%. Given the inconsistencies among published reports regarding the diagnostic accuracy of optical coherence tomography, we performed a systematic review and meta-analysis to assess the accuracy of this method for the diagnosis of bladder cancer, with histopathology as the reference standard.

2. Materials and methods

This study was conducted and reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines [27], and the review protocol was registered in PROSPERO (CRD42019128081).

2.1. Literature search

We searched PubMed, Embase, Medline, Web of Science, and the Cochrane Library database from the earliest date available through October 22, 2018, followed by an update to March 11, 2019. We used the following keywords, separately and in combinations: “bladder tumor”, “bladder cancer”, “bladder carcinoma”, “NMIBC”, “optical coherence tomography”, and “OCT”. To identify additional reference material, manual searches of the reference lists of the review articles identified by our searches were conducted.

2.2. Inclusion and exclusion criteria

Studies were included if they met following criteria: (1) evaluated the accuracy of optical coherence tomography for the diagnosis of bladder cancer; (2) reported sufficient information to allow construction of a diagnostic 2 × 2 contingency table, including true positive, false positive, true negative, and false negative data; (3) histological biopsy was the standard criterion of bladder cancer diagnosis. When there were multiple publications from the same population during an overlapping time period, only the study with the largest series of patients was included.

Studies were excluded if: (1) they were reviews, editorials, opinion pieces, reports of animal model studies, or case reports; (2) they were not written in English; (3) insufficient data was available to allow calculation of the sensitivity and specificity.

2.3. Data selection and extraction

Citations were merged in EndNote version X7 (Thomson Reuters) to facilitate management. Two reviewers independently evaluated all retrieved articles by title and abstract, according to above inclusion criteria, in an un-blinded standardized manner. The reviewers resolved any disagreement through discussion or, if required, adjudication by a third reviewer. Studies that fulfilled the inclusion criteria after full-text screening were finally included in the analysis. Relevant data were extracted from each eligible study, including first author, study year, country of origin, study setting, number of patients enrolled, sex ratio, number of lesions enrolled (a lesion was defined as a biopsy specimen or a biopsy location), tumor stage of the enrolled lesions, type of optical coherence tomography, combined application of optical coherence tomography, optical coherence tomography analysis approach (blinded or real-time), and the sensitivity and specificity of optical coherence tomography for detection of bladder cancer. Data were extracted by two authors independently and consensus reached on all items.

2.4. Quality assessment

The quality of included studies and risk of bias were independently assessed using QUADAS-2 (Quality Assessment of Diagnostic Accuracy Studies) by two reviewers [28]. The QUADAS-2 tool consists of four key domains: 1) patient selection, 2) index test, 3) reference standard, and 4) flow and timing. Risk of bias was judged as “low”, “high”, or “unclear.”

2.5. Statistical analysis

Sensitivity, specificity, positive likelihood ratio, and negative likelihood ratio were subject to meta-analysis. A weighted symmetric summary receiver operating curve was drawn and the area under the curve calculated [29]. For analysis of overall diagnostic accuracy, when data for optical coherence tomography used alone and from optical coherence tomography combined with other imaging techniques (e.g., fluorescence cystoscopy) were both available in a study, the diagnostic accuracy of the combination was selected for the pooled analysis. Between-study heterogeneity was estimated using the I^2 statistic. Significant heterogeneity was defined as an I^2 value exceeding 50%. Pooled results were calculated using a fixed effects model (the Mantel and Haenszel method) when heterogeneity was not significant ($I^2 < 50\%$); otherwise, a random effects model (the DerSimonian and Laird method) was applied. Threshold analysis was performed using the Spearman coefficient (> 0.5 with $P < 0.05$) [30]. Subgroup analysis was conducted according to the optical coherence tomography diagnosis approach: optical coherence tomography used alone, combined with fluorescence cystoscopy, or cross-polarization optical coherence tomography. Meta-regression was applied to detect potentially important covariates exerting a substantial impact on between-study heterogeneity. Moreover, sensitivity analyses were used to evaluate whether any single study dominated the meta-analyses results. Publication bias was examined using Deek’s test. Statistical analyses were conducted using Meta-Disc software (version 1.4; Unit of Clinical Biostatistics, Ramony Cajal Hospital, Madrid, Spain) [31] and STATA 12.0 (Stata Corp LP, College Station, TX, USA).

3. Results

3.1. Description of included studies

The initial literature search and additional reference checking yielded 1098 potentially relevant studies. Most ineligible studies were excluded based on information in the title or abstract, with the remaining 39 studies reviewed in detail. The selection process is presented in Figure S1. Finally, eleven studies, involving more than 586 participants and 1933 lesions, were included in our analysis [16–26]. The main characteristics of the included studies are described in Table 1. Seven studies reported the accuracy of optical coherence tomography for bladder cancer diagnosis [17,20,21,23–26], and three studies reported the diagnostic accuracy of cross-polarization-optical coherence tomography [16,17,19]. In addition, three studies reported the diagnostic accuracy of the combined use of optical coherence tomography and fluorescence cystoscopy [16,20,22], two of which used

Table 1
Basic characteristics of the eligible studies included in the meta-analysis.

Author (year)	Country	Center (n)	Patients (n)	Lesions (n)	Age (mean or median)	Male (%)	Tumor stage (lesions, n)	Pattern of OCT	OCT analysis
Gladkova (2012)	Russia	one	26	79	64.7 (34-79)	69.2	Tis/Ta/T1/T2a:8/14/13/6	combined use of CP-OCT with FC; combined use of OCT with FC	blind
Gladkova (2011)	Russia	one	116	812	NA	NA	all flat lesion[a]	CP-OCT; OCT	blind
Ren (2009)	USA	one	56	110	70	82.1	Tis/Ta-T1/ < T2/ > T2:9/26/35/18	OCT	blind
Kiseleva (2015)	Russia	one	50	68	NA	NA	Tis/T1-T2a:8/14; RCIS:14	CP-OCT	blind
Zagaynova (2008)	Russia /USA	two	80	232/107[b]	NA	NA	Urothelial dysplasia/Tis/Invasive cancer:5/10/2	OCT; combined use of OCT with FC	blind
Manyak (2005)	USA	one	24	87	NA	NA	Papillary/flat lesions:16/5	OCT	blind
Schmidbauer (2009)	Austria	one	66	364	67 (38-84)	74.2	Papillary or flat lesions:232	combined use of OCT with FC	blind
Lerner (2008)	USA	one	32	38	59 (49-84)	78.1	No invasion/invasion:20/11	OCT	real-time
Karl (2010)	Germany	one	52	102	NA (21-91)	NA	HGD/Tis/Ta/T1/T2:2/1/6/3/2	OCT	blind
Hermes (2008)	Germany	NA	NA	142	NA	NA	Carcinoma/CIS:35/2	UHR-OCT	blind
Montagne (2017)	China and France	two	NA	24	NA	NA	NA	full-field OCT	blind

Note: BC, bladder carcinoma; OCT, optical coherence tomography; CP-OCT, cross-polarization optical coherence tomography; FC, fluorescence cystoscopy; UHR-OCT, ultrahigh resolution-OCT; a, flat lesion was defined as a lesion having the following local cystoscopic signs: inflamed, suspicious for neoplasm, red, friable, ulcerated mucosa, papillary or polypoid mass, cobblestone appearance of the mucosa, white plaque-like lesion [Gladkova, et al. 2011]; b, 232 lesions were included in the analysis of OCT used alone and 107 lesions were included in the analysis of combined use of OCT with FC; HGD, high grade dysplasia ; RCIS, recurrence of carcinoma in scar; NA, no data available.

5-aminolevulinic acid [16,20], and the other used hexaminolevulinate [22], as the photosensitizer. All included studies diagnosed bladder cancer using blinded analysis, except for one investigation, which used a real-time analysis approach [23].

3.2. Quality assessment

Most of the studies included in our analysis were of high quality. A high risk of bias in patient selection was detected in one study, due to the inclusion of healthy volunteers in the analysis [19]. Two studies reported the *ex vivo* diagnostic accuracy of optical coherence tomography, which suggested a high risk of bias regarding the applicability of the index test [25,26]. Since three studies assessed the accuracy of cross-polarization-optical coherence tomography for bladder cancer diagnosis, the applicability concerns for their index tests were scored as unclear [16,17,19]. The results of quality assessment of the studies are detailed in Table S1 .

3.3. Overall diagnostic accuracy of optical coherence tomography for bladder cancer

Eleven studies [16–26], including total of 1933 lesions, reported the diagnostic accuracy of per-lesion analysis. The sensitivity ranged from 84% to 100%, while the specificity ranged from 43% to 98%. The corresponding pooled results indicated that optical coherence tomography is able to differentiate malignant from benign lesions with a sensitivity of 94.9% (95% confidence interval: 92.7%–96.6%, I^2 = 54.1%) (Fig. 1) and a specificity of 84.6% (95% confidence interval: 82.6%–86.4%, I^2 = 87.2%) at the per-lesion level (1B). The pooled positive likelihood ratio was 5.83 (95% confidence interval: 3.73–9.12, I^2 = 89.1%) and the pooled negative likelihood ratio was 0.07 (95% confidence interval: 0.05–0.10, I^2 = 43.4%). The area under the curve value for summary receiver operating curve was 0.97 (Fig. 2). No threshold effect was suggested, with a Spearman coefficient of 0.06 (P = 0.87).

3.4. Subgroup analysis of the diagnostic accuracy of optical coherence tomography for bladder cancer

Seven studies [17,20,21,23–26], including a total of 1437 lesions, reported the diagnostic accuracy of optical coherence tomography, used alone, for bladder cancer. Pooled sensitivity and specificity were 87.3% (95% confidence interval: 82.7%–91.1%, I^2 = 77.5%) and 73.9% (95% confidence interval: 71.3%–76.4%, I^2 = 84.2%), respectively (Table 2). The area under the curve value for the summary receiver operating curve was 0.88 (Table 2).

Three studies [16,20,22], with total of 550 lesions, reported the diagnostic accuracy of combined optical coherence tomography and fluorescence cystoscopy. The pooled results suggested that, compared with optical coherence tomography alone, the combined use of optical coherence tomography and fluorescence cystoscopy improved the diagnostic accuracy for bladder cancer, with a sensitivity of 94.3% (95% confidence interval: 90.4%–96.9%, I^2 = 87.0%) and a specificity of 89.2% (95% confidence interval: 85.3%–92.3%, I^2 = 95.3%) (Table 2). The area under the curve value for the summary receiver operating curve was 0.98 (Table 2).

Three studies [16,17,19], including a total of 959 lesions, reported the accuracy of cross-polarization-optical coherence tomography for bladder cancer diagnosis. The pooled results indicated that sensitivity was 92.0% (95% confidence interval: 87.0%–95.6%, I^2 = 0.0%) and the specificity was 84.4% (95% confidence interval: 81.7%–86.9%, I^2 = 35.0%) (Table 2). The area under the curve value for the summary receiver operating curve was 0.95 (Table 2).

3.5. Heterogeneity analysis

A meta-regression was conducted to explore the potential heterogeneity in the analysis of overall diagnostic accuracy of optical coherence tomography for bladder cancer. Three variables were included in the meta-regression: (1) the number of lesions (≥ 100 *vs.* < 100); (2) the type of optical coherence tomography (optical coherence tomography alone *vs.* others); and (3) country of origin (Russia *vs.* others). The meta-regression analysis did not reveal any factor that contributed significantly to the heterogeneity among studies.

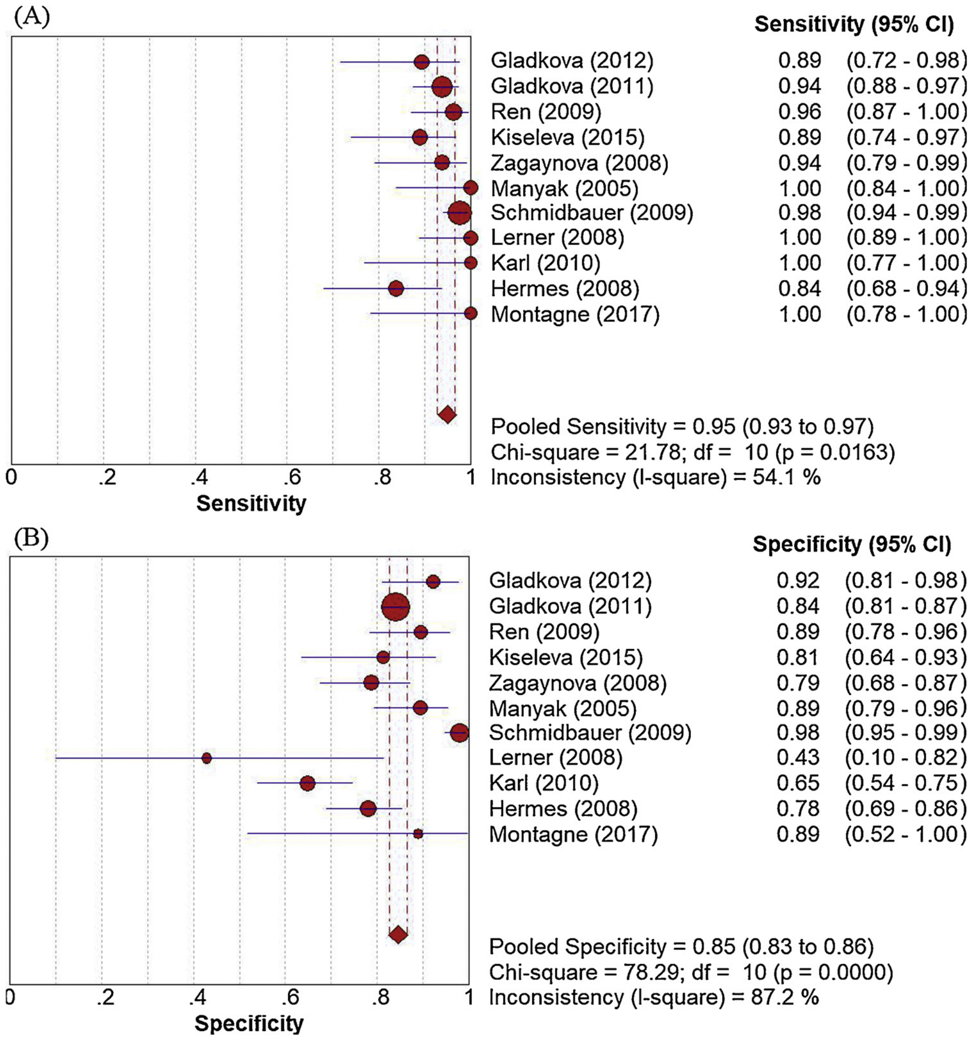

Fig. 1. Forest plot of the pooled sensitivity (A) and specificity (B) of the overall analysis of optical coherence tomography for bladder cancer diagnosis at the per-lesion level (random-effects model).

3.6. Sensitivity analysis

Sensitivity analysis was conducted to evaluate whether any single study dominated the results of the meta-analyses, by sequentially removing individual eligible studies. The results indicated that no individual study significantly altered the overall diagnosis accuracy of optical coherence tomography for bladder cancer, with sensitivity ranging from 93.7% to 95.7% and specificity from 82.4% to 85.9%.

3.7. Publication bias

In the analysis of overall diagnostic accuracy of optical coherence tomography for bladder cancer, Deek's test showed no statistically significant publication bias (P = 0.22) (Figure S2).

4. Discussion

A meta-analysis was published in 2018, which assessed the diagnostic performance of optical coherence tomography to detect bladder cancer [32]; however, there was a major deficiency in this previous meta-analysis as two eligible studies [17,20] were missed and two studies were included inappropriately [33,34]. Furthermore, the literature search dates for that study were reported as being to December 2014; however, two related articles were published after that time [19,26]. Based on the most complete data, this study indicated that optical coherence tomography was able to differentiate bladder cancer from benign lesions, with a sensitivity of 94.9% (95% confidence interval: 92.7%–96.6%) and a specificity of 84.6% (95% confidence interval: 82.6%–86.4%). Our analysis also validates cross-polarization-optical coherence tomography as able to distinguish bladder cancer from normal tissue, with a sensitivity of 92.0% (95% confidence interval: 87.0%–95.6%) and a specificity of 84.4% (95% confidence interval: 81.7%–86.9%). In addition, relative to optical coherence tomography alone, the combination of optical coherence tomography and fluorescence cystoscopy increased the diagnostic accuracy (sensitivity: 94.3% *vs.* 87.3%, specificity: 89.2% *vs.* 73.9%).

Optical coherence tomography can provide high-resolution, subsurface tissue characterization, similar to histology and thus offers the potential for an 'optical biopsy' of bladder cancer; however, given the microscopic imaging modalities required for optical coherence tomography, it is daunting to use this technique to evaluate larger regions or the entire bladder. It has been suggested that optical coherence tomography should be considered as an adjunct to other diagnostic tools, such as white light cystoscopy, fluorescence cystoscopy, or even narrow band imaging [35]. Fluorescence cystoscopy has been widely employed for the diagnosis and follow-up of patients with bladder cancer and achieves a significantly higher rate of bladder cancer detection than white light cystoscopy [36,37]; however, the rate of false positive diagnoses using fluorescence cystoscopy reaches 10%–12%, indicating that it may have lower specificity than white light cystoscopy [37].

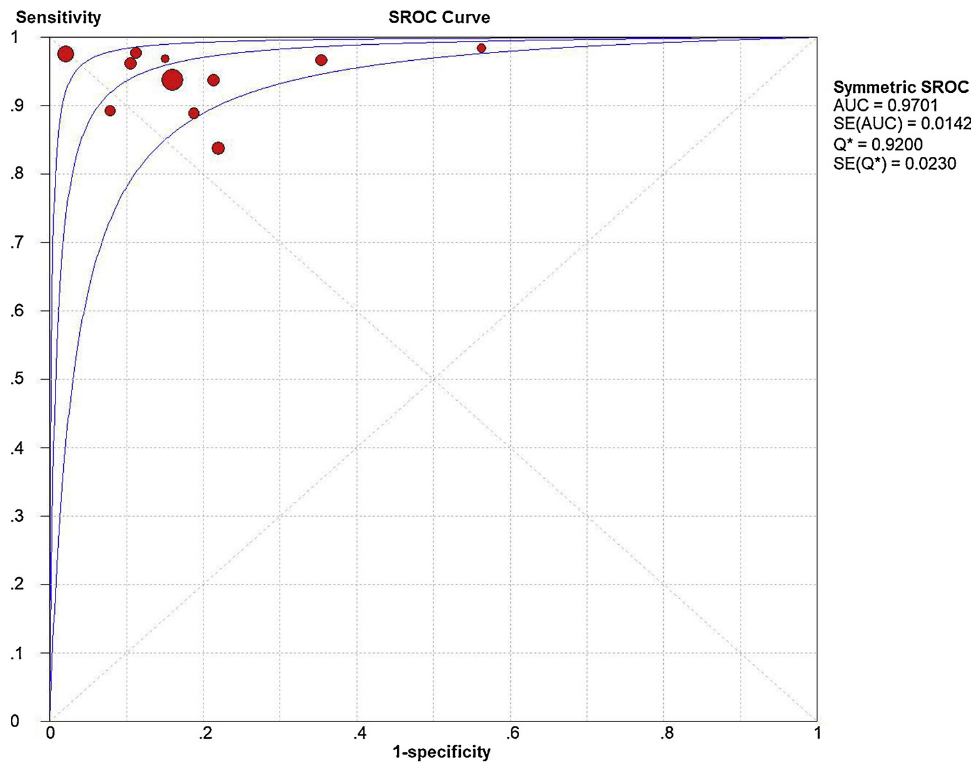

Fig. 2. Summary receiver operating characteristic (SROC) curves with 95% confidence intervals for overall analysis at the per-lesion level. AUC, area under the curve.

Several studies have been conducted to evaluate the diagnostic accuracy of combined optical coherence tomography and fluorescence cystoscopy for the diagnosis of bladder cancer [16,20,22]. Zagaynova et al. [20] reported that, when combined with optical coherence tomography, the positive predictive value of fluorescence cystoscopy was increased from 16% to 43%. The authors suggested that 78.7% of biopsies based on fluorescence cystoscopy positive findings could be avoided based on optical coherence tomography results [20]. Our data also indicate that, relative to optical coherence tomography used alone, combined optical coherence tomography and fluorescence cystoscopy significantly improved diagnostic accuracy, with sensitivity and specificity values of 94.3% (95% confidence interval: 90.4%–96.9%) and 89.2% (95% confidence interval: 85.3%–92.3%), respectively. This was higher than that of optical coherence tomography used alone, which had sensitivity and specificity values of 87.3% (95% confidence interval: 82.7%–91.1%) and 73.9% (95% confidence interval: 71.3%–76.4%), respectively.

A Russian research team reported a series of applications of a special optical coherence tomography modality, cross-polarization-optical coherence tomography, for imaging hard dental tissues, skin, and mucous membranes [16,17,19,38,39]. In contrast to traditional optical coherence tomography, also referred to as polarization-sensitive optical coherence tomography, cross-polarization-optical coherence tomography acquires images derived from cross-polarization and co-polarization scattering simultaneously, and provides information about microstructural and biochemical alterations in depolarizing tissue components [17]. Gladkova et al. [17] evaluated the diagnostic efficacy of cross-polarization-optical coherence tomography compared with optical coherence tomography in 116 patients with localized suspicious flat lesions in the bladder. The results showed that cross-polarization-optical coherence tomography demonstrated significantly better sensitivity (93.7% *vs.* 81.2%, $P < 0.001$) and specificity (84% *vs.* 70.0%, $P < 0.001$) than traditional optical coherence tomography [17]. In addition, Gladkova et al. [16] found that fluorescence cystoscopy and cross-polarization-optical coherence tomography combined exhibited good diagnostic efficacy, with a sensitivity of 89.7%, a specificity of 91.6%, and a diagnostic accuracy of 91.0%, which were significantly higher than the values for combined use of fluorescence cystoscopy and optical coherence tomography (sensitivity, 74.5%; specificity, 70.8%; diagnostic accuracy, 72.1%) for detecting superficial bladder cancer. Our results also demonstrate that the pooled sensitivity and specificity of cross-polarization-optical coherence tomography were superior than those for optical coherence tomography alone (Table 2). These data indicate that there may be justification for increased implementation of cross-polarization-optical coherence tomography in bladder cancer diagnosis.

In addition to optical coherence tomography, several other technologies have the potential to markedly improve the diagnosis of bladder cancer, including photodynamic diagnosis, narrow-band imaging and confocal laser endomicroscopy. Due to the lack of direct comparisons between optical coherence tomography and these other technologies, their diagnostic accuracies are generally considered to be comparable [9,10,40,41]; however, Ren et al. reported data from experiments on a mouse bladder carcinoma in situ model indicating that the sensitivity and specificity of optical coherence tomography, white light cystoscopy, narrow-band imaging, and fluorescence cystoscopy were 93% and 94%, 3% and 78%, 90% and 28%, 45% and 100%, respectively [42]. Given the obvious differences between animal models and humans, whether optical coherence tomography has superior diagnostic accuracy than other technologies requires further investigation.

Although optical coherence tomography has been demonstrated to have advantages for bladder cancer diagnosis, several issues require further exploration. First, the diagnostic efficacy of optical coherence tomography in real-time, where results are interpreted during procedure, has rarely been reported. To date, only one study, conducted in 32 participants, reported the diagnostic accuracy of optical coherence tomography in real-time analysis [23]. The time required for image acquisition for one patient, and the complexity of real-time image interpretation, are also rarely reported. Second, the recurrence rate

Table 2
Results of subgroup analysis of different OCT patterns in bladder cancer diagnosis.

	Number of studies (lesions)	Sensitivity (95% CI, %)	Heterogeneity (I^2)	Specificity (95% CI, %)	Heterogeneity (I^2)	Positive LR (95% CI)	Heterogeneity (I^2)	Negative LR (95% CI)	Heterogeneity (I^2)	AUC
OCT	7 (1437)	87.3 (82.7-91.1)	77.5	73.9 (71.3-76.4)	84.2	3.62 (2.60-5.04)	79.8	0.15 (0.09-0.27)	26.7	0.88
CP-OCT	3 (959)	92.0 (87.0-95.6)	0.0	84.4 (81.7-86.9)	35.0	6.07 (5.01-7.36)	12.4	0.09 (0.05-0.15)	0.0	0.95
Combined use of OCT with FC	3 (550)	94.3 (90.4-96.9)	87.0	89.2 (85.3-92.3)	95.3	7.78 (1.33-45.44)	96.5	0.09 (0.01-0.72)	92.8	0.98

Note: AUC, area under the curve; CI, confidence interval; OCT, optical coherence tomography; CP-OCT, cross-polarization optical coherence tomography; FC, fluorescence cystoscopy; LR, likelihood ratio.

following optical coherence tomography-guided transurethral resection of bladder tumor remains inconclusive, as no studies have been published on this topic. Third, given its depth of penetration, optical coherence tomography can be used to stage bladder cancer; however, the diagnostic efficacy of optical coherence tomography for different cancer stages (e.g., carcinoma in situ or papillary tumors) has rarely been reported. Fourth, there has been a lack of evaluation of the cost-effectiveness of optical coherence tomography for detection and follow-up of bladder cancer. Finally, given the limitations of the field of view of optical coherence tomography, the diagnostic efficacy of this technique combined with other diagnostic approaches, such as white light cystoscopy, narrow-band imaging, or cytology, requires further exploration.

Several limitations of this meta-analysis should be addressed. First, there was significant heterogeneity among the included studies. Different inclusion and exclusion criteria, variable diagnostic criteria, and observer experience bias may have contributed to this heterogeneity. Although we performed subgroup analysis and meta-regression, the results did not identify all the reasons underlying the heterogeneity among studies. Second, assessment of the included studies showed that not all were of high quality, which may have resulted in some bias in the final statistical data. Third, several studies were conducted by the same investigator group in Russia, and a proportion of the included studies were not conducted in recent years, which may limit the reproducibility of the results in clinical practice.

5. Conclusions

In conclusion, our meta-analysis indicates that optical coherence tomography can accurately differentiate malignant from benign bladder lesions. Further, compared with optical coherence tomography alone, the combination of optical coherence tomography and fluorescence cystoscopy significantly improved the accuracy of bladder cancer diagnosis.

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Authors' contribution

Yi-Quan Xiong: Manuscript writing.
Jing Tan and Yan-Mei Liu: Data analysis.
Fang-Fei You, Yong-Zhi Li and Min-Yi Zhang: Citation evaluation and data extraction.
Qing Chen and Kang Zou: Critical revision of the manuscript.
Xin Sun: Project development.

Declarations of interest

None.

Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

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None.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.pdpdt.2019.06.006.

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