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Original Article

ORIGINAL ARTICLE

Comparing the clinical application values of the Degree of Ulcerative Colitis Burden of Luminal Inflammation (DUBLIN) score and Ulcerative Colitis Endoscopic Index of Severity (UCEIS) in patients with ulcerative colitis

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Abstract

Background: The significance of endoscopic evaluation in the diagnosis and management of ulcerative colitis (UC) has been widely recognized. Over the years, scholars have established several endoscopic scores. Herein, we assessed the clinical application value of the Mayo Endoscopic Subscore (Mayo ES), the Degree of Ulcerative Colitis Burden of Luminal Inflammation (DUBLIN) score, and the Ulcerative Colitis Endoscopic Index of Severity (UCEIS) score in UC patients, by comparing their correlation with disease activity and their predictive potential for treatment response and clinical outcomes.
Methods: UC patients hospitalized from September 2015 to September 2019 were retrospectively analysed. We employed Spearman's rank correlation coefficient to assess the linear association of the assessed endoscopic scores with the clinical parameters. The receiver-operating characteristic curve was applied to evaluate the predictive capabilities of the endoscopic scores for treatment escalation and 1-year readmission.
Results: A total of 178 patients were enrolled; most of them (82%) suffered moderate or severe colitis. Among them, 48 (27%) patients received treatment escalation and 59 (33%) were readmitted within 1 year. The DUBLIN and UCEIS scores demonstrated higher correlations with clinical parameters than the Mayo ES. The DUBLIN scores significantly differed between patients with mild, moderate, and severe colitis (all $P < 0.001$). The UCEIS scores demonstrated the best predictabilities for treatment escalation and 1-year readmission with an area under the curve of 0.88 and 0.75, respectively. Compared to the UCEIS and DUBLIN scores, the predictive capabilities of the Mayo ES for treatment escalation (both $P < 0.001$) and 1-year readmission ($P < 0.001$ and $P = 0.002$, respectively) were lower. The UCEIS scores exhibited a significant difference between the steroid-responsive group and the steroid-dependent or steroid-refractory group (both $P < 0.001$), while no significant differences in the Mayo ES and DUBLIN scores were found among the three groups (both $P > 0.05$).

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Conclusion: This study demonstrates that both the DUBLIN and UCEIS scores outperform the Mayo ES in assessing disease severity and predicting treatment response and clinical outcomes in UC patients.

Key words: Mayo Endoscopic Subscore; Degree of Ulcerative Colitis Burden of Luminal Inflammation score; Ulcerative Colitis Endoscopic Index of Severity; ulcerative colitis

Introduction

Ulcerative colitis (UC) is a complex immune-mediated condition characterized by continuous mucosal inflammation of the colon with increased morbidity and a negative impact on quality of life [1, 2]. Compelling evidence indicates that in the course of UC, mucosal healing is associated with better outcomes, such as an elevated rate of steroid-free remission, decreased need for colectomy, and low hospitalization rates [3]. With mucosal healing gradually becoming an important treatment goal for UC patients, the application of endoscopic indices both in clinical trials and in practice is on the rise [4, 5]. To date, several scoring systems for endoscopic UC severity assessment exist [5]. Of note, the Mayo Endoscopic Subscore (Mayo ES) and the Ulcerative Colitis Endoscopic Index of Severity (UCEIS) are currently the most promising instruments, reliable in assessing endoscopic disease activity.

The Mayo ES is the endoscopic component of the Mayo Clinic Index, previously described in 1987 by Schroeder and colleagues [6]. Based on endoscopic findings, this scoring system defines four grades of endoscopic disease activity. However, it does not distinguish superficial from deep ulcers; also, significant overlap between grades 1 and 2 may arise [7]. Nevertheless, the Mayo ES remains the most widely adopted scoring system in clinical practice because its simplicity and utility allow the description of the degree of endoscopic activity [8]. In 2012, Travis *et al.* [9] described the UCEIS, and evaluated its reliability and initial validation the following year [10]. Notably, this index evaluates the three most reproducible endoscopic findings (vascular pattern, bleeding, erosions, and ulcers) to achieve a scale of 0–8, providing finer details that distinguish the endoscopic severity of UC. Furthermore, numerous reports have demonstrated the significance of the UCEIS in predicting treatment escalation and adverse outcomes in ulcerative colitis [11–13]. Currently, it is mostly used in clinical trials due to the relatively complex scoring method. These two scores primarily focus on mucosal appearance, without considering disease extent. Rowan *et al.* [14] in 2019 established a simple endoscopic score, the Degree of Ulcerative Colitis Burden of Luminal Inflammation (DUBLIN), to quantify inflammatory burden in ulcerative colitis, calculated as a product of the Mayo ES (0–3) and the Montreal classification for disease extent (E1–E3). Researchers consider that the DUBLIN score may be a simple but useful tool in daily clinical practice and may facilitate personalized treatment of UC patients. However, it required further validation. The current study aimed to evaluate the clinical utility of the above three endoscopic scoring indices in UC patients, by comparing their correlation with disease activity and their potential to predict treatment response and clinical outcomes.

Patients and methods

Study subjects

We retrospectively analysed the medical records of 696 UC patients hospitalized at the Affiliated Hospital of Qingdao University (Qingdao, China) from September 2015 to September 2019. UC was diagnosed on the basis of the established standard clinical, radiological, and pathological criteria. Exclusion criteria included: (i) patients who did not receive colonoscopy before treatment or underwent self-medication before colonoscopy; (ii) patients with incomplete data on biochemical or hematological examinations; (iii) patients with prior colon surgery, Crohn's colitis, IBD unclassified, concomitant infectious colitis, or colorectal neoplasia; (iv) patients who underwent high-cost examinations or treatments not related to UC during hospitalization, such as coronary CT angiography or endoscopic polypectomy. Eventually, 178 patients were included in this study (Figure 1). This study followed guidelines stipulated by the World Medical Association Declaration of Helsinki. The Institutional Review Board of the Ethics Committee of the Affiliated Hospital of Qingdao University reviewed and approved the study protocol (QYFY WZLL 26044).

Data collection

Clinical data recorded during hospitalization were collected for each patient, including: (i) demographic data, information regarding medical history, disease duration; (ii) disease-related clinical information, including daily stool frequency, the amount of blood in the stool, temperature, pulse rate, diagnosis, the extent of colonic involvement, severity, treatment, length of stay, and hospitalization costs; (iii) baseline colonoscopy appearances; (iv) laboratory parameters, including C-reactive protein (CRP), hemoglobin, albumin, leukocyte count, and platelet count.

Clinical assessment of disease severity and activity

We evaluated the clinical severity of patients using the Truelove and Witts Severity Index [15]. Based on the daily number of stools, fecal blood, pulse, body temperature, hemoglobin, and erythrocyte sedimentation rate or CRP, patients were classified as mild, moderate, or severe. The Mayo Clinic Index (also known as the Mayo score) was employed to assess the clinical disease activity, ranging from 0 to 12, whereby scores for stool frequency, rectal bleeding, findings on endoscopy, and physician's global assessment were recorded [6].

Endoscopic evaluation

Colonoscopy was conducted using Olympus-CF-H260 endoscopy (9.8-mm diameter, Tokyo, Japan). Colonoscopy images were obtained from the Picture Archiving and Communication System of the hospital. Two experienced IBD endoscopic physicians (X.D. and J.G.), blinded to the clinical and histologic information, and familiar with the use of the Mayo ES, Montreal classification, and the UCEIS, performed image analysis independently. Scores were recorded contemporaneously. A senior physician (Z.T.) resolved any disagreement.

All cases were evaluated using the Mayo ES, DUBLIN score, and UCEIS score. The Mayo ES was classified into four categories: 0, normal or inactive disease; 1, mild disease (erythema, decreased vascular pattern, mild friability); 2, moderate disease (marked erythema, lack of vascular pattern, friability, erosions); 3, severe disease (spontaneous bleeding, ulceration) [6].

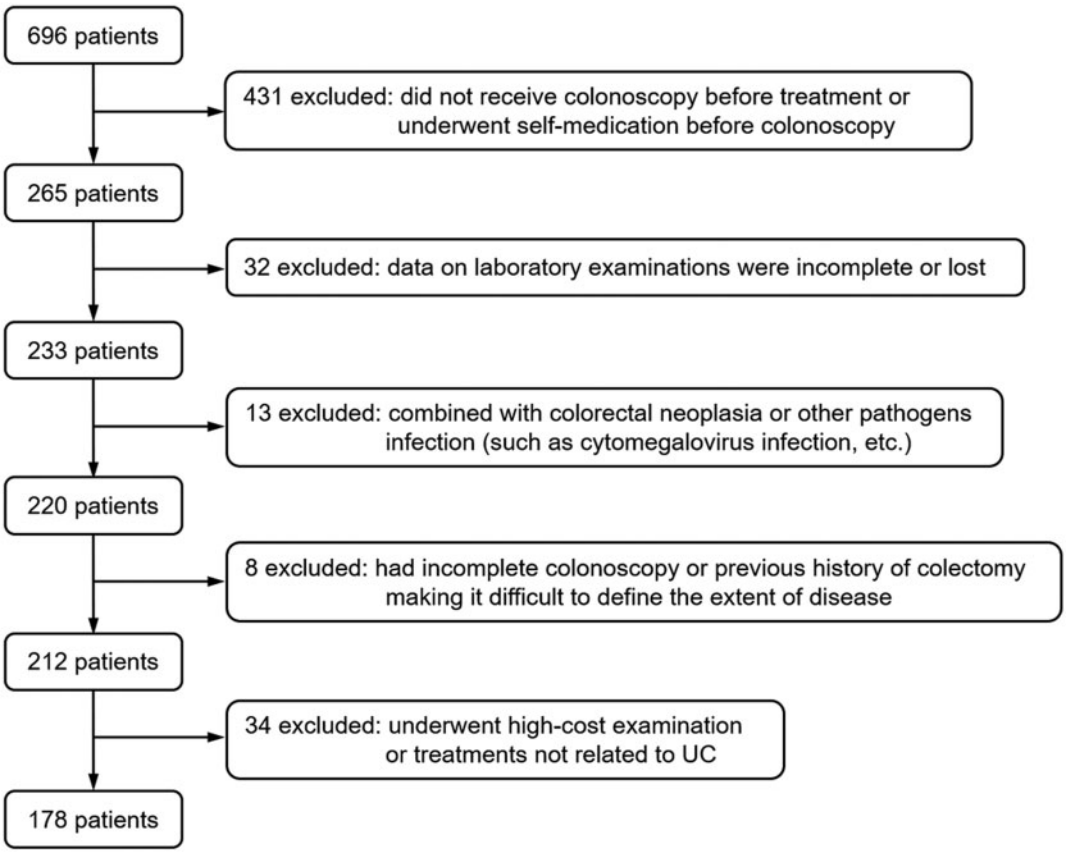

Figure 1. Flow chart for the inclusion of patients in the study analysis

Through Montreal classification, we defined the extent of lesion involvement as follows: E1, ulcerative proctitis (involvement limited to the rectum); E2, left-sided colitis (involvement limited to the portion of the colorectum distal to the splenic flexure); E3, extensive colitis (involvement extended proximal to the splenic flexure) [16]. The DUBLIN score was calculated as a product of the Mayo ES and Montreal classification for disease extent (Supplementary Table 1) [14]. The UCEIS score was calculated as a simple sum of the following three items: vascular pattern (scored 0–2); bleeding (scored 0–3); erosions and ulcers (scored 0–3) [9, 10]. Hence, we used a 0–8 range in the UCEIS score (Supplementary Table 2).

Statistical assessments

Using Spearman's rank correlation coefficient, we compared the linear relationship between the Mayo ES, the DUBLIN score, and the UCEIS score, as well as the correlation of the assessed endoscopic scores with the Mayo Clinic Index, laboratory parameters, length of stay, and hospitalization costs. The strength of correlation was defined as follows: 0.9–1.0, very strong; 0.7–0.9, strong; 0.5–0.7, moderate; <0.50, weak [17]. Non-parametric variables were compared using the Mann–Whitney *U* test or the Kruskal–Wallis *H* test. The receiver-operating characteristic (ROC) curve was used to evaluate the predictive power of the Mayo ES, DUBLIN score, and UCEIS score for treatment escalation and readmission within 1 year. All statistical data were analysed using the Statistical Package for the Social Sciences 22.0 software (SPSS Inc.).

Results

Patient characteristics

Of the 178 patients, 96 (53.9%) were male; the median age was 48.8 (range 16.9–76.3) years; the median duration of the disease was 24.3 (range 0.1–425.8) months. Approximately 90% of the patients were characterized by extensive colitis (58%) or left-sided colitis (31%). The medians of the Mayo ES, DUBLIN scores, and UCEIS scores are presented in Table 1.

Correlations between the Mayo ES, DUBLIN, and UCEIS

The correlations between the Mayo ES, DUBLIN scores, and UCEIS scores were analysed, as outlined in Figure 2. The Mayo ES demonstrated a significant correlation with the DUBLIN scores ($r = 0.702$, $P < 0.001$; Figure 2A) and UCEIS scores ($r = 0.671$, $P < 0.001$; Figure 2B). Also, a strong correlation existed between the DUBLIN scores and UCEIS scores ($r = 0.742$, $P < 0.001$; Figure 2C). Each Mayo ES corresponded to three DUBLIN scores and four to six UCEIS scores (Figure 2). With these results, the DUBLIN and UCEIS scores could reflect the actual endoscopic findings more accurately and provide more clinical information than the Mayo ES.

Correlations between endoscopic scores and clinical/laboratory parameters

The median Mayo Clinic Index was 10 [interquartile range (IQR), 8–11]. The Mayo Clinic Index demonstrated moderate correlation with the Mayo ES ($r = 0.619$, $P < 0.001$) and strong correlation with the DUBLIN ($r = 0.766$, $P < 0.001$) and UCEIS ($r = 0.760$, $P < 0.001$) scores. Serum parameters of enrolled UC patients are presented in

Table 1. Baseline characteristics, endoscopic scores, and laboratory parameters of patients with ulcerative colitis

Characteristic	Values ($n = 178$)
Female, *n* (%)	82 (46.1)
Age, years, median (range)	48.8 (16.9–76.3)
Disease duration, months, median (range)	24.3 (0.1–425.8)
Montreal classification, *n* (%)	
E1 = Proctitis	19 (10.7)
E2 = Left-sided colitis	56 (31.5)
E3 = Extensive colitis	103 (57.9)
Truelove and Witts Severity Index, *n* (%)	
Mild	32 (18.0)
Moderate	66 (37.1)
Severe	80 (44.9)
Mayo Clinic Index, median (IQR)	10 (8–11)
Mayo endoscopic subscore, *n* (%)	
1	8 (4.5)
2	57 (32.6)
3	113 (63.5)
DUBLIN score, median (IQR)	6 (6–9)
UCEIS score, median (IQR)	5 (4–6)
Therapy, *n* (%)	
5-Aminosalicylates	178 (100)
Corticosteroids	48 (27.0)
Immunomodulators	11 (6.2)
Infliximab	7 (3.9)
Thalidomide	2 (1.7)
Colectomy	2 (1.7)
Response to steroid treatment, *n* (%)	
Sensitive	28 (58.3)
Dependent	14 (29.2)
Refractory	6 (12.5)
Length of hospital stay, *n* (%)	
≤14 days	144 (80.9)
>14 days	34 (19.1)
Hospitalization costs, CN¥, median (range)	9,553 (3,325–109,287)
Readmission within 1 year, *n* (%)	59 (33.1)
C-reactive protein, mg/L, median (IQR)	6.4 (2.1–28.7)
Hemoglobin, g/L, median (IQR)	122.0 (97.0–136.5)
Albumin, g/L, median (IQR)	36.4 (31.4–41.2)
Leukocyte count, $\times 10^9$/L, median (IQR)	6.9 (5.6–8.8)
Platelet count, $\times 10^9$/L, median (IQR)	293.5 (218.5–390.0)

IQR, interquartile range; DUBLIN, Degree of Ulcerative colitis Burden of Luminal Inflammation; UCEIS, Ulcerative Colitis Endoscopic Index of Severity.

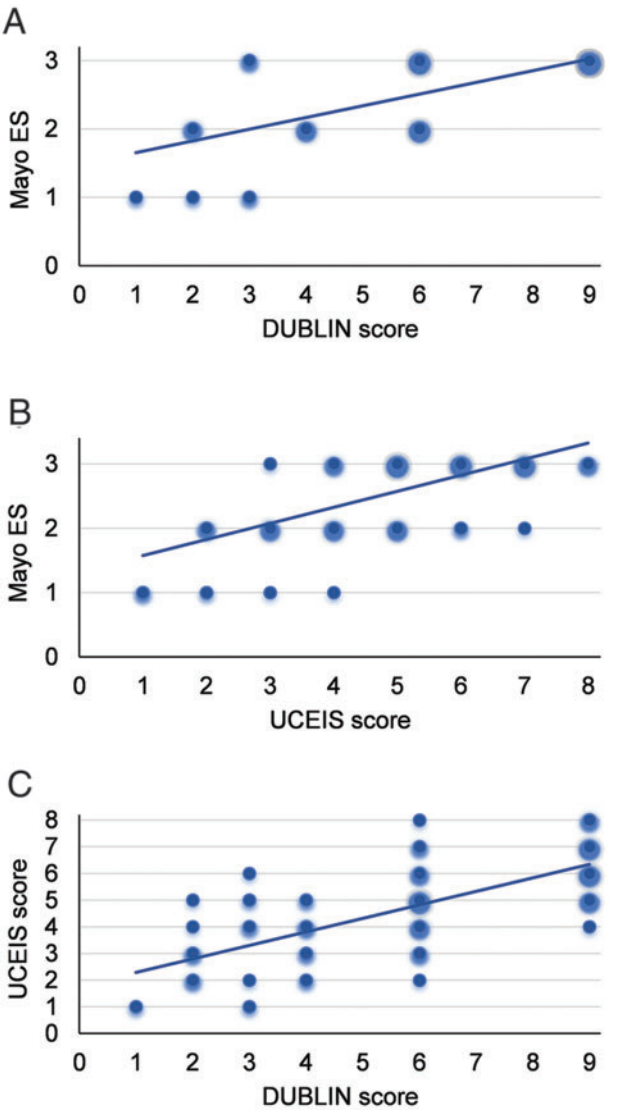

Figure 2. Correlations between the Mayo ES, DUBLIN score, and UCEIS score in patients with ulcerative colitis ($n = 178$). (A) A strong correlation between the Mayo ES and the DUBLIN ($r = 0.702$, $P < 0.001$). (B) A moderate correlation between the Mayo ES and the UCEIS ($r = 0.670$, $P < 0.001$). (C) A strong correlation between the DUBLIN and the UCEIS ($r = 0.742$, $P < 0.001$).

Table 1. Correlations between assessed endoscopic scores and laboratory parameters are outlined in Table 2. The Mayo ES was weakly correlated with CRP, hemoglobin, and albumin; however, it was not associated with leukocyte count and platelet count. The DUBLIN score was moderately correlated with CRP and albumin, but weakly correlated with hemoglobin, leukocyte count, and platelet count. Similarly, the UCEIS scores showed a moderate correlation with CRP, but a weak correlation with albumin, hemoglobin, leukocyte count, and platelet count. Based on these results, the DUBLIN and UCEIS scores showed higher correlations with clinical/laboratory parameters than the Mayo ES. In contrast to the UCEIS scores, the DUBLIN scores could better reflect the inflammatory burden of UC patients.

Comparison of the Mayo ES, DUBLIN, and UCEIS in different clinical severities of UC patients

Following the Truelove and Witts Severity Index, we classified patients as mild ($n = 32$), moderate ($n = 66$), and severe ($n = 80$). Significant differences among groups concerning the Mayo ES, DUBLIN, and UCEIS were revealed (Kruskal–Wallis *H* test, all $P < 0.001$). Nevertheless, further pairwise comparison showed distinctions in the three endoscopic scores in reflecting the severity of the disease. The DUBLIN scores of patients in all groups were significantly different from each other [median (IQR): 4 (2–5.5) vs 6 (4–6) vs 9 (6–9); all $P < 0.001$]. No statistical difference was found in the Mayo ES between moderate and severe patients [median (IQR): 2 (2–3) vs 3 (3–3); $P = 0.549$], as well as the UCEIS scores between mild and moderate patients [median (IQR): 4 (3–5) vs 5 (4–5); $P = 0.091$] (Figure 3).

Comparison of the Mayo ES, DUBLIN, and UCEIS in predicting treatment escalation of UC patients

All the 178 enrolled patients were treated with 5-aminosalicylic acid (5-ASA) (Table 1). Among them, 130 patients (73.0%) were treated with 5-ASA alone or combined with corticosteroid

Table 2. Correlations between endoscopic scores and clinical/laboratory parameters in 178 patients with ulcerative colitis

Parameter	Mayo ES		DUBLIN		UCEIS	
	Spearman coefficient (*r*)	*P*-value	Spearman coefficient (*r*)	*P*-value	Spearman coefficient (*r*)	*P*-value
Mayo Clinic Index	0.619	<0.001	0.766	<0.001	0.760	<0.001
C-reactive protein	0.357	<0.001	0.581	<0.001	0.592	<0.001
Hemoglobin	–0.182	0.015	–0.415	<0.001	–0.304	<0.001
Albumin	–0.271	<0.001	–0.508	<0.001	–0.446	<0.001
Leukocyte count	0.111	0.141	0.355	<0.001	0.345	<0.001
Platelet count	0.060	0.430	0.293	<0.001	0.240	0.001
Length of stay	0.424	<0.001	0.678	<0.001	0.641	<0.001
Hospitalization costs	0.346	<0.001	0.592	<0.001	0.523	<0.001

Mayo ES, Mayo Endoscopic Subscore; DUBLIN, Degree of Ulcerative colitis Burden of Luminal Inflammation; UCEIS, Ulcerative Colitis Endoscopic Index of Severity.

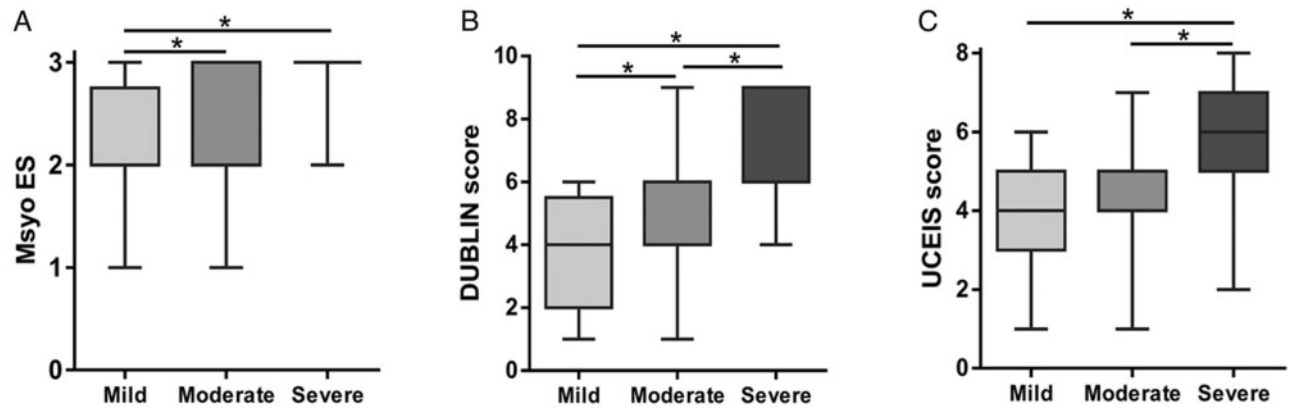

Figure 3. Comparisons of endoscopic scores among the mild ($n = 32$), moderate ($n = 66$), and severe ($n = 80$) groups (*$P < 0.001$). (A) Mayo ES; (B) DUBLIN score; (C) UCEIS score.

enema and classified into the 5-ASA alone group. The other 48 patients (27.0%) also received systemic corticosteroids (methylprednisolone, prednisone), immunomodulators (azathioprine, mercaptopurine), biologics (infliximab), thalidomide, or colectomy therapy, considered as treatment escalation. First, we used the non-parametric Mann–Whitney *U* test to compare the endoscopic scores between the 5-ASA alone group and the treatment-escalation group. Notably, patients who received 5-ASA treatment alone exhibited a significantly lower Mayo ES [median (IQR): 3 (2–3) vs 3 (3–3); $Z = –4.054$, $P < 0.001$], DUBLIN score [median (IQR): 6 (4–9) vs 9 (9–9); $Z = –6.359$, $P < 0.001$], and UCEIS score [median (IQR): 5 (4–6) vs 7 (6–7); $Z = –7.220$, $P < 0.001$] (Figure 4A–C).

To compare the predictive potential of the evaluated endoscopic scores on the treatment escalation, we performed ROC analysis subsequently. The UCEIS score exhibited the best predictive capability with an area under the ROC curve (AUC) of 0.88 (sensitivity 92%, specificity 74%, cut-off value 5.5). Also, the DUBLIN score, with an AUC of 0.82 (sensitivity 87%, specificity 74%, cut-off value 7.5), demonstrated a good predictive capability. Compared to the UCEIS and DUBLIN scores, the predictive capability of the Mayo ES with an AUC of 0.68 (sensitivity 92%, specificity 44%, cut-off value 2.5) was lower (both $P < 0.001$) (Figure 4D–F).

Comparison of the Mayo ES, DUBLIN, and UCEIS in predicting the response to steroid therapy

Of 48 patients who received corticosteroids therapy, 28 (58.3%) were steroid-responsive, 14 (29.2%) were steroid-dependent, and 6 (12.5%) were steroid-refractory (Table 1). We compared the Mayo ES, DUBLIN, and UCEIS in the above three patient groups. Both the Mayo ES and DUBLIN score showed no difference among the three groups (Kruskal–Wallis *H* test, $P = 0.091$ and 0.327, respectively; Figure 5A and B). Although no statistical difference was noted in the UCEIS scores between steroid-dependent and steroid-refractory patients ($P = 0.566$), both were significantly higher than those of steroid-responsive patients (both $P < 0.001$; Figure 5C). This suggested that UCEIS scores may offer more advantages in predicting the response of UC patients to steroid therapy.

Correlations between endoscopic scores and length of stay and hospitalization costs

The median length of stay was 9 days (range, 2–56) and CN¥ 9,553 (range, 3325–109287) was reported as the median of hospitalization costs. The correlations between the three assessed endoscopic scores and length of stay and hospitalization costs are presented in Table 2. Compared to the Mayo ES and the UCEIS scores, the DUBLIN scores showed the highest correlation coefficient with the length of stay ($r = 0.678$, $P < 0.001$) and hospitalization costs ($r = 0.592$, $P < 0.001$). Besides, the Mayo ES and the UCEIS scores demonstrated a significant correlation with length of stay and hospitalization costs.

Comparison of the Mayo ES, DUBLIN, and UCEIS in predicting the readmission within 1 year

Up to 59 patients (33.1%) were rehospitalized within 1 year of discharge (Table 1). We categorized all patients into

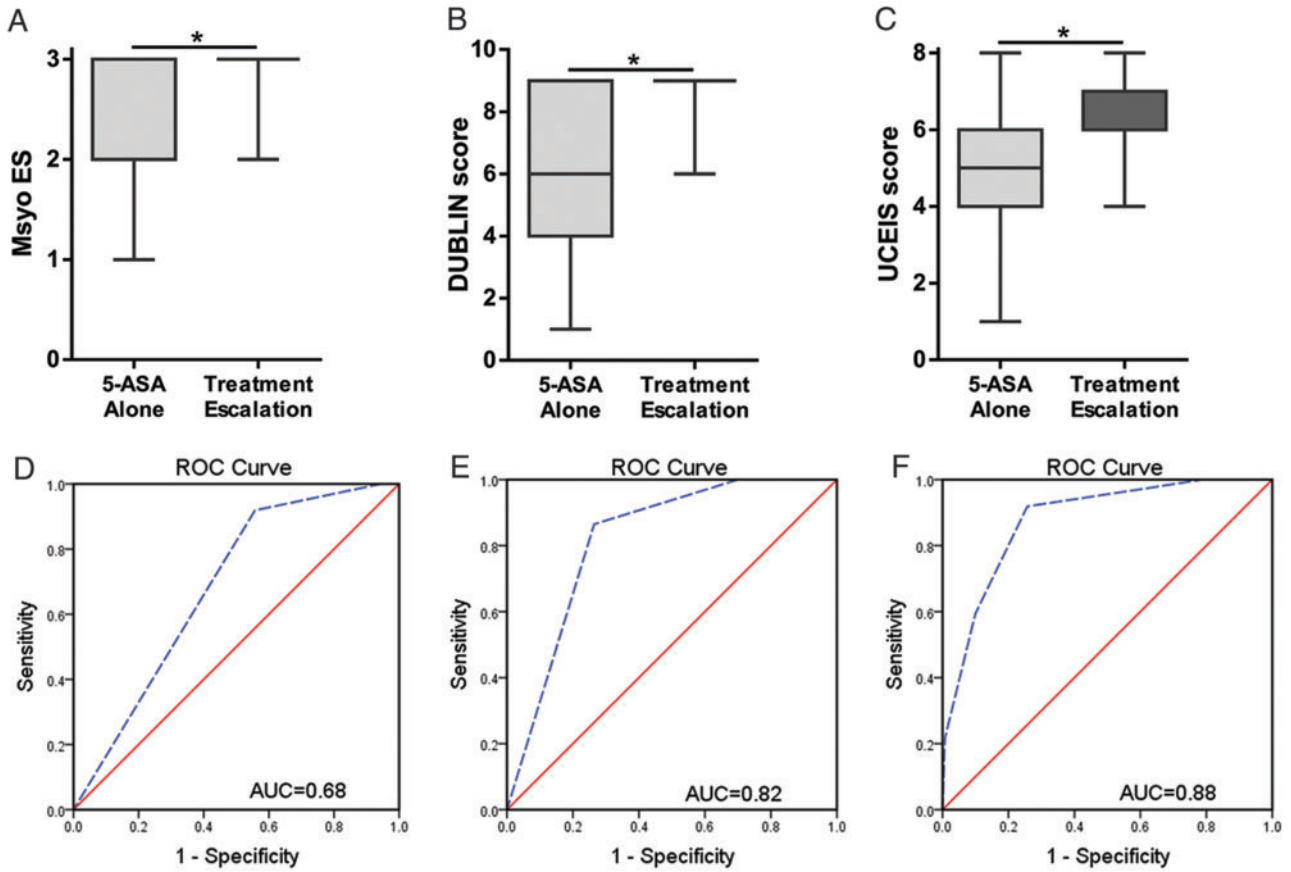

Figure 4. Performances of endoscopic scores in predicting treatment escalation of patients with ulcerative colitis. Comparisons of the Mayo ES (A), DUBLIN score (B), and UCEIS score (C) between the 5-ASA alone group ($n = 130$) and the treatment-escalation group ($n = 48$) [Median (interquartile range); *$P < 0.001$]. Based on the receiver-operating characteristic curves, the Mayo ES (D) shows an inferior predictive value for treatment escalation, while the DUBLIN score (E) and the UCEIS score (F) demonstrate a moderate predictive value.

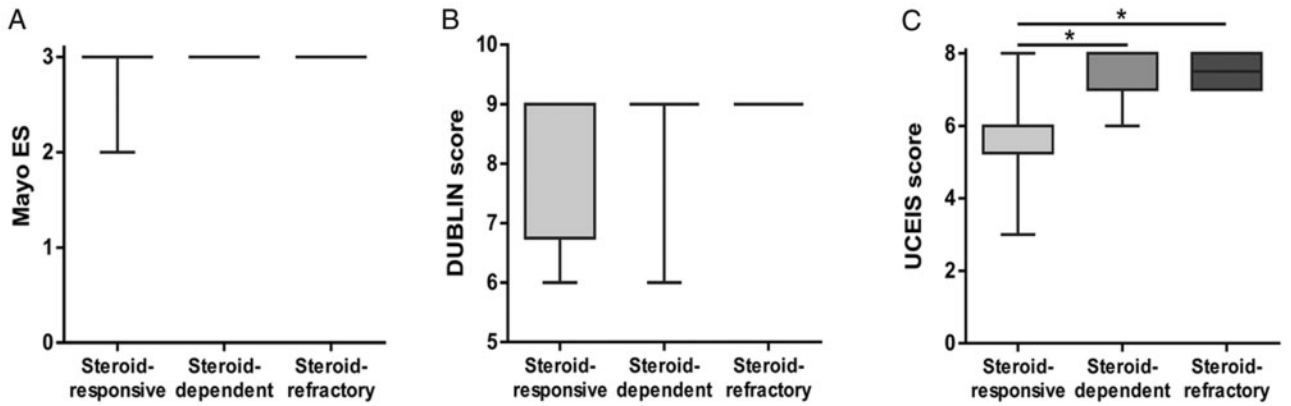

Figure 5. Comparisons of endoscopic scores among the steroid-responsive ($n = 28$), steroid-dependent ($n = 14$), and steroid-refractory ($n = 6$) groups [Median (interquartile range); *$P < 0.001$]. (A) Mayo ES; (B) DUBLIN score; (C) UCEIS score.

readmission and non-readmission groups to explore whether these assessed endoscopic scores reflected short-term prognosis. Patients who were readmitted within 1 year showed significantly higher DUBLIN scores [median (IQR): 9 (6–9) vs 6 (4–9); $Z = -4.205$, $P < 0.001$] and UCEIS scores [median (IQR): 6 (5–7) vs 5 (4–6); $Z = -5.448$, $P < 0.001$]. Although the two UC patient groups exhibited the same Mayo ES median and IQR [3 (2–3)], we used the non-parametric Mann–Whitney *U* test to establish the statistical difference ($Z = -2.354$, $P = 0.019$) (Figure 6A–C).

Using ROC-curve analysis, we compared the predictive ability of the assessed endoscopic scores on the readmission within 1 year. Analogously, the UCEIS score exhibited the best predictive capability with an AUC of 0.75 (sensitivity 68%, specificity 75%, cut-off value 5.5). The predictive capability of the DUBLIN score, with an AUC of 0.68 (sensitivity 58%, specificity 70%, cut-off value 7.5), was lower than that of the UCEIS score with no statistical difference ($P = 0.053$). The Mayo ES, with an AUC of 0.59 (sensitivity 75 %, specificity 42%, cut-off value 2.5), demonstrated inferior

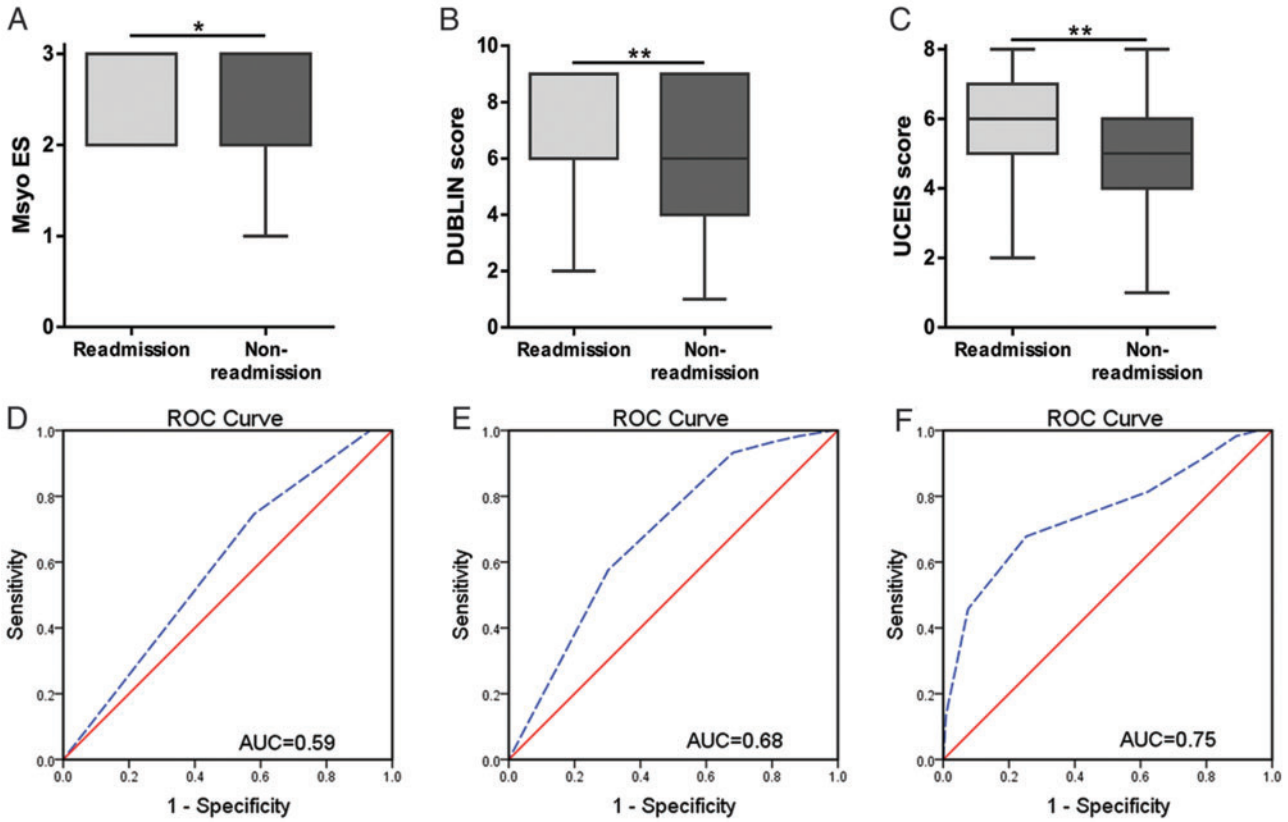

Figure 6. Performances of endoscopic scores in predicting readmission rates within 1 year. Comparisons of the Mayo ES (A), DUBLIN score (B), and UCEIS score (C) between the readmission group ($n = 59$) and the non-readmission group ($n = 119$) [Median (interquartile range); *$P < 0.05$, ** $P < 0.001$]. Based on the receiver-operating characteristic curves, the Mayo ES (D) and the DUBLIN score (E) show a poor predictive value, while the UCEIS score (F) demonstrates a moderate predictive value.

predictive capability, significantly lower than the UCEIS ($P < 0.001$) and the DUBLIN scores ($P = 0.002$) (Figure 6D–F).

Discussion

Herein, we explored the clinical utility of the Mayo ES, DUBLIN, and UCEIS in patients with UC. Notably, both the DUBLIN and the UCEIS showed better application potential than the Mayo ES in reflecting disease activity and predicting clinical response and outcomes. Meanwhile, the DUBLIN and the UCEIS exhibited individual merits in distinct utility evaluations. We concluded that the DUBLIN score may prove more valuable to predict the clinical severity of UC patients. Also, the UCEIS score could better reflect the responses of UC patients to steroid therapy.

There is growing evidence on the association of mucosal healing with a higher health-related quality of life and a superior long-term prognosis [4, 18–20]. The main therapeutic goal of UC has shifted from clinical remission to endoscopic healing and histological healing, to achieve better long-term outcomes [21]. Therefore, an accurate assessment of mucosal damage via endoscopy is of particular importance. Since the first description of endoscopic features in UC by Truelove and Witts [15] in 1955, several endoscopic indices have been established to evaluate endoscopic activity in clinical trials or practice for UC, including the Baron score, the Mayo ES, the Rachmilewitz Score, the UCEIS score, and the Ulcerative Colitis Colonoscopic Index of Severity (UCCIS) [5, 8]. Currently, the Mayo ES and the UCEIS are ranked first and/or second by the International Organization For the Study of Inflammatory Bowel Disease (IOIBD) group for endoscopic definitions of remission and response [8]. Following recent reports, the UCEIS reflects clinical outcomes and prognosis more accurately than the Mayo ES, such as predicting patients' response to immunomodulators or biological therapy and the need for colectomy [12, 22, 23]. However, these scores only focus on mucosal appearance, leaving out disease extent. Rowan *et al.* [14] in 2019 innovatively proposed a DUBLIN score, which integrated the Mayo ES to evaluate mucosal appearance and Montreal classification to describe disease extent. Herein, we compared the clinical application value of the Mayo ES, DUBLIN score, and UCEIS score for the first time, and assessed whether the DUBLIN score had more advantages in clinical-practice settings.

The Mayo ES has a three-point scale. The DUBLIN score was calculated as a product of the Mayo ES and Montreal classification for disease extent. Notably, each Mayo ES corresponded to three DUBLIN scores due to the varying disease extent. The UCEIS scoring system comprised three items with a sum score ranging from 0 to 8: vascular pattern (0–2), bleeding (0–3), erosions and ulcers (0–3). Consequently, each Mayo ES corresponded to four to six UCEIS scores in our study. Meanwhile, there was a moderate correlation between the Mayo ES and the UCEIS score, and a strong correlation between the DUBLIN score and the Mayo ES, and the UCEIS score. Of note, all of the three endoscopic scores were consistent in reflecting the degree of endoscopic activity of UC. Furthermore, the DUBLIN score made the evaluation of UC more comprehensive, whereas the UCEIS score demonstrated a more detailed endoscopic severity of mucosal lesions.

Elsewhere, Rowan *et al.* [14] suggested that the DUBLIN score could evaluate the total inflammatory burden of disease in UC

patients due to its correlation with objective inflammatory markers, including fecal calprotectin, CRP, and albumin. Other researchers had also explored the correlation of the UCEIS score or the Mayo ES with laboratory markers [11, 22, 24]. Besides, de Jong *et al.* [11] reported a moderate correlation of the UCEIS Simple Clinical Colitis Activity Index values, a clinical disease activity score. The Mayo Clinic Index is a popular and extensively used parameter for evaluating UC disease activity [25, 26]. Hence, in addition to the laboratory parameters CRP, hemoglobin, albumin, leukocyte, and platelet count, we selected the Mayo Clinic Index to assess the correlation of the above endoscopic scores with the inflammatory burden and clinical activity of patients. Notably, the Mayo ES demonstrated an obvious disadvantage in the above assessment compared to the other two scoring systems. The DUBLIN and UCEIS scores were strongly correlated with the Mayo Clinic Index; however, the UCEIS score lacked consideration of disease extent. Nevertheless, the DUBLIN score performed slightly better than the UCEIS score in terms of reflecting the inflammatory burden of UC.

In our hospital, we have widely adopted the Mayo ES in clinical practice for many years; it is easy to score. On the other hand, in most cases, the Montreal classification for disease extent is asked to be indicated in the endoscopic diagnosis. Thus, calculating the DUBLIN scores is simplified at the time of endoscopy. The UCEIS scoring method is relatively complex; currently, it is mostly applied in clinical studies or clinical trials [27, 28]. Rowan *et al.* [14] suggested that the DUBLIN score may improve the operability for UC endoscopic assessment. However, we were curious to elucidate whether the endoscopic scoring system could guide the choice of treatment, which is crucial in clinical practice.

Herein, based on the Truelove and Witts Severity Index, we compared the Mayo ES, DUBLIN, and UCEIS in UC patients with different clinical severity; this was vital to predict the severity of UC patients and develop treatment options [1, 15, 29]. Our results demonstrated that the Mayo ES could not distinguish moderate from severe colitis and the UCEIS score could not distinguish between mild and moderate colitis. Notably, only the DUBLIN score revealed the differences in varying disease severities. This may be attributed to the correlation of bowel frequency, temperature, pulse rate, and serum albumin with disease extent [30].

Nevertheless, UCEIS scores might have a better predictive potential for treatment escalation than the Mayo ES and the DUBLIN score in UC patients. Herein, although all the three assessed endoscopic scores demonstrated a significant difference between the 5-ASA alone group and the treatment-escalation group, UCEIS scores showed the highest AUC (0.88) based on ROC analysis, which was close to the results (AUC = 0.93) reported by de Jong *et al.* [11]. Thus, UCEIS scores may offer a better predictive ability for treatment escalation than the Mayo ES and DUBLIN scores.

Of note, the proportion of patients undergoing treatment escalation was low (27%). In fact, infliximab was the only available biological agent for UC patients in our hospital before 2019. The high cost had promoted most patients to abandon this treatment option. Meanwhile, the “step-up therapy” was still widely adopted in our hospital in the past few years, although this treatment strategy might be relatively conservative. Moreover, owing to concerns about the adverse reactions of systemic corticosteroids and immunomodulators, a substantial proportion of moderate–severe UC patients develop resistance to these therapeutic agents. Thereupon, after comprehensive evaluation of the patients’ condition, we attempted corticosteroid enema in some patients to manage the symptoms. Because corticosteroid enema was not systemic administration, we classified this subset of patients into the 5-ASA alone group rather than the treatment-escalation group for statistical analysis.

All patients who received treatment escalation in our study were treated with oral or intravenous steroid therapy. Notably, systemic corticosteroids are suitable for patients with moderate to severe activity and those with mild activity who are unresponsive to 5-ASA [3]. Because of its lower economic cost, steroid therapy remains the preferred treatment escalation in China. It is therefore important to predict the patient’s response to steroid therapy. In another study, Carbonnel *et al.* [31] confirmed the association of severe endoscopic lesions with an increased risk of failure of intensive intravenous steroid therapy. However, our results revealed that the three patient groups with distinct responses to steroid therapy could not be distinguished according to the Mayo ES or the DUBLIN score. Notably, only the UCEIS score in the steroid-responsive group was significantly lower than in the steroid-dependent and steroid-refractory patient groups. To explain this, the UCEIS had more detailed scoring criteria for the severity of mucosal lesions. Thus, UCEIS scores exhibited some predictive potential for the response to steroid therapy.

Moreover, patients with severe UC tend to be characterized by a longer hospital stay, higher cost of hospitalization, and a higher likelihood of readmission within 1 year [32–34]. Therefore, we believed that if the endoscopic scoring system could comprehensively predict the above indicators, it would be helpful to devise healthcare plans in clinical practice. By comparing the Mayo ES, DUBLIN, and UCEIS, we found that the DUBLIN score exhibited the highest correlation with length of stay and hospitalization costs, whereas the UCEIS scores showed the most predictive value for 1-year readmission.

There were several limitations to our study. First, being a retrospective study, the vast majority of patients did not receive secondary endoscopy after symptom remission. Thus, the remission rate and some medium- to long-term prognostic indicators were not analysed. Patients were enrolled from a single center with a limited sample size and most of them were excluded without biochemical, hematological measurements, and total colonoscopy assessment before treatment; this may have introduced selection bias. Furthermore, as our hospital did not have the conditions for fecal calprotectin examination before September 2019, this parameter could not be included in the analysis. The endoscopic scoring for all enrolled patients was based on still images rather than a dynamic video. Although most endoscopies currently rated the presence of any friability as the Mayo ES 2 [35], we still adopted the original Mayo ES for scoring and statistics for consistency with the DUBLIN score calculation. Finally, in our hospital, the treatment strategy for UC patients was relatively conservative until 2019; this may contribute to the high 1-year readmission rate, which consequently could influence the accuracy and reliability of the study results. Nevertheless, we have future plans to conduct a prospective study on the above issues to make these findings more valuable.

In conclusion, the present findings demonstrate that DUBLIN and UCEIS scores outperform the Mayo ES in evaluating disease activity in UC patients and predicting treatment response and clinical outcomes. Of note, both have their advantages. The DUBLIN score might be more suitable for application in daily clinical practice owing to its simple scoring method and the provision of information about disease extent and severity. Meanwhile, the UCEIS score can better predict treatment

response and thus is appropriate for the development of individualized treatment plans for UC patients.

Supplementary Data

Supplementary data is available at *Gastroenterology Report* online.

Authors' Contributions

X.F.Z., X.L.D., J.G., and Z.B.T. conceived of and designed the project. X.F.Z., P.L., H.L.C., and S.B.J. collected the data. X.F.Z., P.L., and S.J.W. analysed and interpreted the data. X.F.Z. drafted the manuscript. All authors read and approved the final manuscript.

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Conflict of Interest

None declared.

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