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Real-world effectiveness and safety of upadacitinib in Korean patients with inflammatory bowel disease: a single-center retrospective study

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Background/Aims: Upadacitinib, a selective Janus kinase 1 inhibitor, has demonstrated efficacy in clinical trials for inflammatory bowel disease (IBD); however, real-world data from Asian populations remain limited. **Methods:** We conducted a single-center retrospective study to evaluate the real-world effectiveness and safety of upadacitinib in Korean patients with ulcerative colitis (UC) or Crohn's disease (CD). Adult patients who initiated upadacitinib between July 2021 and November 2024 were included. Symptom-based clinical activity was assessed using patient-reported outcomes at baseline and 6 months. Adverse events and surgical interventions were also documented. **Results:** Forty patients (28 CD, 12 UC) were analyzed. At 6 months, symptom-based clinical remission was achieved in 82.4% of CD and 81.8% of UC patients, with clinical response rates of 88.2% and 90.9%, respectively. No clinical or treatment-related factors were significantly associated with remission in univariate analyses. Adverse events occurred in 57.5% of patients, all grade 1, and no treatment discontinuations were required. Six patients with CD required surgery during treatment. **Conclusions:** Upadacitinib was effective and well tolerated over 6 months in Korean patients with moderate-to-severe IBD, including those with biologic-experienced patients. These findings support its use in routine clinical practice, while highlighting the need for prospective studies to confirm its long-term safety and efficacy in Asian populations. **(Intest Res, Published online)**

Key Words: Upadacitinib; Inflammatory bowel diseases; Ulcerative colitis; Crohn disease

INTRODUCTION

Upadacitinib is an oral, selective Janus kinase 1 (JAK1) inhibitor[1-4] that has emerged as a novel treatment option for inflammatory bowel disease (IBD), including both ulcerative colitis (UC) and Crohn's disease (CD).[1,5-7] Clinical trials have demonstrated its efficacy in inducing and maintaining remission in patients with moderate to severe disease, particularly those who have failed conventional or biologic therapies.[8-10] Based on these results, upadacitinib has been approved for the treatment of UC in many countries, and recent evidence also supports its use in CD.

However, real-world data on the effectiveness and safety of upadacitinib remain limited,[11] particularly among Asian populations. Patients in clinical practice often differ from those enrolled in trials in terms of disease phenotype, comorbidities, and prior biologic exposure. In Korea, upadacitinib has only recently become available following reimbursement approval, and experience with its use in daily practice is still limited. Given the ethnic and phenotypic differences in IBD and the

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need to validate global trial results in regional contexts, real-world data from Korean patients are essential to inform treatment strategies. Therefore, this study aimed to evaluate the real-world clinical effectiveness and safety of upadacitinib in Korean patients with UC or CD. We focused on clinical remission, response, treatment durability, and safety, and explored differences according to prior biologic exposure. To our knowledge, this represents one of the first real-world analyses of upadacitinib in Korean IBD patients.

METHODS

1. Study Design and Patient Selection

This was a single-center, retrospective observational study conducted at Samsung Medical Center to evaluate the real-world clinical effectiveness and safety of upadacitinib in patients with IBD. Adult patients diagnosed with UC or CD who were prescribed upadacitinib at the outpatient clinic or during hospitalization in the Department of Gastroenterology between July 1, 2021, and November 30, 2024, were considered for inclusion. Diagnoses were confirmed by standard clinical, endoscopic, and histopathological criteria. Moderate-to-severe disease was defined at treatment initiation as a Crohn's Disease Activity Index (CDAI) ≥220 for CD, and a total Mayo score ≥6 with an endoscopic subscore ≥2 for UC. Patients were included if they received at least 1 dose of upadacitinib and had available clinical outcome data at baseline and at least 1 follow-up time point. Those patients prescribed upadacitinib for non-IBD indications (e.g., rheumatoid arthritis, atopic dermatitis) were excluded.

2. Ethical Approval

The study protocol was reviewed and approved by the Institutional Review Board of Samsung Medical Center (IRB No. 2025-05-167) and was conducted in accordance with the Declaration of Helsinki. The written informed consent was waived by the IRB.

3. Upadacitinib Treatment and Concomitant Medications

Upadacitinib was initiated at a dose of 45 mg once daily in all patients. Dose reduction was considered at week 12 in CD and at week 8 in UC, and all dose adjustments during follow-up were documented. Only 5-aminosalicylic acid was used concomitantly; no other immunosuppressants were administered.

4. Clinical Data Collection and Outcomes

Demographic and clinical data, including age, sex, IBD subtype, disease duration, prior biologic exposure, and details of upadacitinib therapy, were retrospectively collected. Patients were assessed at baseline (within 1 week prior to treatment initiation) and at approximately 6 months after starting upadacitinib. The primary outcome was the change in patient-reported outcomes (PRO2) from baseline to 6 months. For CD, PRO2 was defined as the composite of weekly diarrhea frequency and abdominal pain episodes (PRO2[1]). For UC, PRO2 was defined as the composite of daily stool frequency and rectal bleeding scores (PRO2[2]), with stool frequency scored as 0 (normal), 1 (1–2 above normal), 2 (3–4 above normal), and 3 (≥5 above normal), and rectal bleeding scored as 0 (none), 1 (streaks of blood), 2 (obvious blood), and 3 (mostly blood). Clinical remission was defined as ≤3 stools/day with abdominal pain score ≤1 for CD (4 patients met criteria at baseline) and loose stool frequency ≤1 with rectal bleeding score=0 for UC, whereas clinical response was defined as a reduction in PRO2 components (stool frequency plus abdominal pain) from baseline for CD or a ≥50% reduction in PRO2 from baseline for UC.

Fecal calprotectin (FC) levels were evaluated when available, with concentrations <150 μg/g considered indicative of mucosal remission. Adverse events (AEs) and surgical interventions during the follow-up period were also documented.

5. Adverse Event Assessment

Safety was evaluated by documenting any AEs reported during follow-up, including type, severity, and whether the event led to treatment discontinuation or hospitalization. AEs were categorized and summarized descriptively.

6. Statistical Analysis

Analyses were performed using R software (version 4.3.2, R Foundation for Statistical Computing, Vienna, Austria). Continuous variables were expressed as medians with interquartile ranges (IQRs); categorical variables as frequencies and percentages. Comparisons between groups were conducted using the chi-square test for categorical variables and the Wilcoxon signed-rank test for continuous variables. The Wilcoxon signed-rank test was also used to assess changes in PRO2 scores over time. A P-value <0.05 was considered statistically significant. Changes in PRO2 scores from baseline to 6 months were also graphically represented using box plots for CD and UC cohorts, generated with R software.

Table 1. Baseline Characteristics

Characteristics	Total (n = 40)
Age (yr)	33.5 (26.8–44.3)
Male sex	32 (80.0)
Age at diagnosis (yr)	22.5 (16.8–31.8)
Diagnosis	
CD	28 (70.0)
UC	12 (30.0)
Location (CD only)	
Terminal ileum (L1)	3 (10.7)
Colon (L2)	2 (7.1)
Ileocolon (L3)	20 (71.4)
Ileocolon and upper GI (L3+L4)	3 (10.7)
Behavior (CD only)	
Non-stricture, non-penetrating (B1)	6 (21.4)
B1+p	8 (28.6)
Stricture (B2)	7 (25.0)
B2+p	4 (14.3)
Penetrating (B3)	1 (3.6)
B3+p	2 (7.1)
Disease extent (UC only)	
E2 (left sided)	5 (41.7)
E3 (extensive)	7 (58.3)
Bio-experienced	
Naive	2 (5.0)
Experienced	38 (95.0)
Multi-biologic failure	
None	2 (5.0)
1	7 (17.5)
≥ 2	31 (77.5)
MOA	6.0 (3.0–7.0)
Anti-TNF	6 (15.0)
VDZ	0
UST	3 (7.5)
Small cell	0
Anti-TNF+VDZ	4 (10.0)
Anti-TNF+UST	14 (35.0)
Anti-TNF+VDZ+UST	8 (20.0)
Anti-TNF+VDZ+UST+small cell[a]	1 (2.5)
Anti-TNF+UST+small cell[b]	1 (2.5)
VDZ+UST+small cell[c]	1 (2.5)
Baseline score (CD only)	
Loose stool (numbers/wk)	12.0 (2.0–54.3)
Abdominal pain score	2.0 (2.0–3.0)
PRO2[1]	14.0 (3.8–57.3)

(Continued to the next)

Table 1. Continued

Characteristics	Total (n = 40)
Baseline score (UC only)	
Stool frequency	2.0 (2.0–3.0)
Rectal bleeding	2.0 (1.8–3.0)
PRO2[2]	5.0 (3.8–5.0)
Baseline CRP (mg/dL)	0.82 (0.28–1.83)
Baseline fecal calprotectin (μg/g) (n = 29)	395.0 (121.4–636.7)
Previous surgery	12 (30.0)
CD	11
UC	1
Disease duration (yr)	10.0 (4.75–14.0)

Values are presented median (interquartile range) or number (%).
Small molecule agents: [a]filgotinib (clinical trial), [b]CCR9 antagonist+ozanimod (clinical trial), [c]tofacitinib (clinical trial).
CD, Crohn's disease; UC, ulcerative colitis; GI, gastrointestinal; B1, non-stricturing, non-penetrating; B2, stricturing; B3, penetrating; p, perianal modifier (perianal fistula); E2, left-sided colitis; E3, extensive colitis; MOA, mechanism of action; anti-TNF, tumor necrosis factor inhibitor; VDZ, vedolizumab; UST, ustekinumab; CRP, C-reactive protein; PRO2[1], composite of diarrhea episodes/week and abdominal pain episodes/week in CD; PRO2[2], composite of stool frequency and rectal bleeding in UC.
Diarrhea and abdominal pain reported as episodes/week. Stool frequency: 0, 0–2/day; 1, 1–2 more than normal; 2, 3–4 more than normal; 3, ≥ 5 more than normal. Rectal bleeding: 0, none; 1, streaks of blood; 2, obvious blood; 3, mostly blood.

RESULTS

1. Patient Characteristics

A total of 40 patients with IBD were included, comprising 28 patients (70.0%) with CD and 12 patients (30.0%) with UC. Thirty-two patients (80.0%) were male. The median age was 33.5 years (IQR, 26.8–44.3 years) and the age at diagnosis was 22.5 years (IQR, 16.8–31.8 years). The mean disease duration was 10.0 years (IQR, 4.75–14.0 years). At baseline, the median weekly diarrhea frequency was 12.0 episodes (IQR, 2.0–54.3) and mean abdominal pain score was 2.0 (IQR, 2.0–3.0) among patients with CD. For patients with UC, the mean stool frequency score was 2.0 (IQR, 2.0–3.0) and mean rectal bleeding score was 2.0 (IQR, 1.8–3.0). Only 2 patients (5.0%) were biologic-naive. Additional baseline clinical characteristics are detailed in Table 1. The maintenance dose was 30 mg in all but 4 patients. Among those receiving a 15 mg maintenance dose, 3 patients had CD and 1 patient had UC.

2. Clinical Outcomes

1) Crohn's Disease

Among the 28 patients with CD, symptom-based clinical ac-

Table 2. Clinical Response at 6 Months of Upadacitinib Therapy in CD and UC

	No. (%)
Clinical remission	
CD (n = 17, PRO2[1])	14 (82.4)
UC (n = 11, PRO2[2])	9 (81.8)
Clinical response	
CD (n = 17, PRO2[1])	15 (88.2)
UC (n = 11, PRO2[2])	10 (90.9)

Clinical remission: CD defined as ≤3 stools/day and abdominal pain score ≤1 (4 patients met criteria at baseline); UC defined as loose stool frequency ≤1 and rectal bleeding score = 0. Clinical response: CD defined as a reduction in PRO2 components (stool frequency+abdominal pain) from baseline; UC defined as ≥50% reduction in PRO2 from baseline.
CD, Crohn's disease; UC, ulcerative colitis; PRO2, composite index (PRO2[1] for CD: diarrhea+abdominal pain; PRO2[2] for UC: stool frequency+rectal bleeding).

tivity was assessed in 28 patients at baseline and in 17 patients at the 6-month follow-up. The mean daily loose stool frequency decreased significantly from 28.57 at baseline to 6.82 at 6 months ($P<0.004$). Abdominal pain scores also improved markedly from a mean of 2.14 to 0.59 ($P<0.001$) (Supplementary Table 1). At 6 months, clinical remission—defined for CD as ≤3 stools/day and an abdominal pain score ≤1—was achieved in 14 of 17 patients (82.4%), and clinical response—defined as a reduction in PRO2 components (stool frequency plus abdominal pain) from baseline—was observed in 15 of 17 patients (88.2%), as summarized in Table 2. The distribution and reduction of PRO2 scores over time in CD patients are illustrated in Fig. 1, demonstrating a significant decrease from baseline ($P<0.001$). Additionally, at the standard 12-week evaluation point, clinical remission and response were observed in 14 (70.0%) and 13 (65.0%) of the 28 CD patients, respectively (Supplementary Table 2).

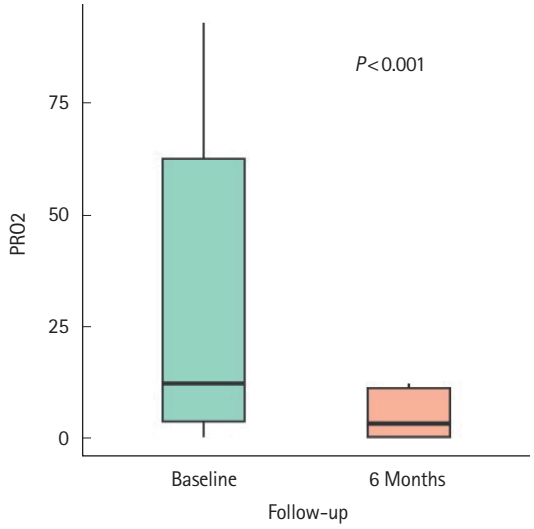

Fig. 1. Change in patient-reported outcomes (PRO2) scores over 6 months in patients with Crohn's disease. PRO2 was defined as the composite of weekly diarrhea frequency and abdominal pain episodes.

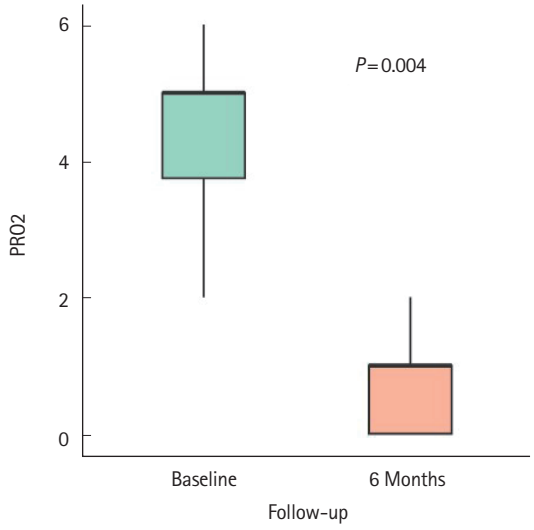

Fig. 2. Change in patient-reported outcomes (PRO2) scores over 6 months in patients with ulcerative colitis. PRO2 was defined as the composite of daily stool frequency and rectal bleeding scores.

2) Ulcerative Colitis

Among the 12 patients with UC, symptom-based outcomes were evaluated at baseline and at the 6-month follow-up. Stool frequency decreased significantly from a mean of 2.33 at baseline to 0.73 at 6 months ($P=0.005$), while rectal bleeding scores declined from a mean of 2.08 at baseline to 0.09 at 6 months ($P=0.005$), as detailed in Supplementary Table 3. At 6 months, clinical remission—defined for UC as a loose stool frequency ≤1 and a rectal bleeding score of 0—was achieved in 9 of 11 patients (81.8%), and clinical response—defined as a ≥50% reduction in PRO2 from baseline—was observed in 10 of 11 patients (90.9%), as shown in Table 2. The temporal changes in PRO2 scores are presented in Fig. 2, highlighting a significant reduction at 6 months compared to baseline ($P=0.004$). Additionally, at the 8-week assessment, clinical remission and response were achieved in 6 (66.7%) and 8 (88.9%) of the 12 UC patients, respectively (Supplementary Table 2).

3. Composite Clinical and Biomarker-Based Remission and Response

FC levels at 6 months were available for a subset of patients.

Table 3. Analysis of Factors Associated with Remission

Variable	Non-remission	Remission	*P*-value
No.	5	23	
Sex			1.00
Male	4 (80.0)	17 (73.9)	
Female	1 (20.0)	6 (26.1)	
Age (yr)	30.0 (29.0–33.0)	38.0 (27.5–46.5)	0.70
Age at diagnosis (yr)	18.0 (15.0–24.0)	27.0 (17.0–35.0)	0.07
Smoking			0.91
Missing	0	3 (13.0)	
Non-smoker	3 (60.0)	14 (70.0)	
Ex-smoker	1 (20.0)	3 (13.0)	
Current-smoker	1 (20.0)	3 (13.0)	
Multi-biologic failure			0.52
None	0	2 (8.7)	
1	0	3 (13.0)	
≥ 2	5 (100.0)	18 (78.3)	
MOA	7.0 (5.0–7.0)	6.0 (4.0–6.0)	0.50
CRP baseline (mg/dL)	0.8 (0.1–0.8)	0.6 (0.3–1.8)	0.52
Previous surgery	4 (80.0)	6 (26.1)	0.08

Values are presented as number (%) or median (interquartile range).
MOA, mechanism of action; CRP, C-reactive protein.

Among those with CD who achieved PRO2-based clinical remission, 3 of 5 patients (60.0%) also had FC < 150 μg/g. In UC, 2 of 4 patients (50.0%) who met PRO2 remission criteria demonstrated concurrent mucosal remission based on FC (data not shown).

4. Factors Associated with Clinical Remission

Univariate analyses were performed to identify factors associated with clinical remission at 6 months. Variables examined included sex, age, age at diagnosis, smoking status, multi-biologic failure, mechanism of action (MOA) of prior biologics, baseline C-reactive protein (CRP), and history of previous surgery. None of these factors demonstrated a statistically significant association with clinical remission (sex, $P = 1.00$; age, $P = 0.70$; age at diagnosis, $P = 0.07$; smoking, $P = 0.91$; multi-biologic failure, $P = 0.52$; MOA, $P = 0.50$; baseline CRP, $P = 0.52$; previous surgery, $P = 0.08$). Detailed results are provided in Table 3.

5. Safety and Surgical Outcomes

AEs were reported in 23 of 40 patients (57.5%), all of which were classified as grade 1. The median total exposure duration was 244 days (IQR, 155–358 days). The most frequently observed AEs included dermatologic manifestations such as acne (12 patients), dermatitis (3 patients), and rash or pruritus, followed by anemia (8 patients), hyperlipidemia (3 patients), herpes zoster (3 patients), and influenza (1 patient). Importantly, no AEs led to treatment discontinuation or hospitalization. A comprehensive summary of AEs is presented in Table 4.

Table 4. Adverse Events (n = 40)

Total	No. (%)
None	16
Herpes zoster	3
Dermatitis[a]	3
Acne	12
Hyperlipidemia	3
Anemia[b]	8
Influenza	1

[a]Dermatitis: erythema and pruritus requiring dermatologic consultation.
[b]Anemia: requiring iron supplementation or transfusion of red blood cells.

During the follow-up period, 6 patients with CD required surgical intervention due to inadequate clinical response or disease-related complications. Indications for surgery included perianal fistula, abscess formation, intestinal strictures, and entero-cutaneous fistulas. No surgical procedures were performed in patients with UC. Six patients with long-standing, complicated CD underwent surgery during upadacitinib treatment, all of whom had stricturing or penetrating behavior and prior biologic failure. Detailed surgical characteristics and outcomes are presented in Supplementary Table 4.

DISCUSSION

This study presents one of the earliest real-world evaluations of upadacitinib in Korean patients with IBD, assessing its clinical effectiveness and safety in both UC and CD. Unlike most pivotal trials that relied solely on composite indices, our study prioritized symptom-based clinical outcomes to better reflect patient experience in real-world practice. In Korea, upadacitinib has only recently been approved for reimbursement, and clinical experience remains limited. Therefore, this study addresses an important gap by providing real-world data on treatment outcomes in this population.

In UC patients, 81.8% achieved clinical remission and 90.9% showed a clinical response at 6 months. These outcomes are comparable to or higher than those reported in pivotal ran-

domized trials, such as U-ACHIEVE and U-ACCOMPLISH, where 8-week remission rates ranged from 26% to 34% and response rates from 60% to 73%.[8] In a prospective real-world study by Friedberg et al.,[12] the 8-week remission rate reached 81.5%, while a domestic multicenter study at Asan Medical Center reported a 16-week remission rate of 83.1%.[13] A European multicenter cohort from the Apulian IBD network showed an 8-week UC remission rate of 52% and a response rate of 39%.[14] This study presents one of the earliest real-world evaluations of upadacitinib in Korean patients with IBD, assessing its clinical effectiveness and safety in both UC and CD. These findings support the favorable short-term safety profile of upadacitinib in real-world settings, and the clinical outcomes observed in our cohort fall within the expected range reported across diverse populations and study designs.[15]

In CD, the 6-month clinical remission and response rates were 82.4% and 88.2%, respectively. These are consistent with the pooled remission rate of 41% and response rate of 62% reported in a 2024 meta-analysis.[16] Friedberg et al.[12] reported a remission rate of 70.6% in CD patients at week 8, while the Apulian cohort demonstrated a 12-week remission rate of 16% and response rate of 66%.[13] Although clinical endpoints vary across studies, our findings reinforce the real-world efficacy of upadacitinib in CD as well. Given that CDAI and Mayo scores are primarily used for reimbursement documentation in clinical practice, this study emphasized symptom-based parameters (e.g., diarrhea frequency, abdominal pain, stool frequency, and rectal bleeding) as the main clinical outcomes. Composite indices such as CDAI and Mayo were included as complementary markers.

One of the practical advantages of upadacitinib is its oral route of administration, which may enhance patient adherence and convenience. Nevertheless, safety concerns persist regarding class effects of JAK inhibitors,[17] including herpes zoster,[18] thromboembolic events,[19,20] and hepatotoxicity.[21] In our study, 57.5% of patients experienced AEs, most commonly dermatologic manifestations, infections, and changes in lipid profiles. All events were grade 1, and no treatment discontinuations occurred. Three cases of herpes zoster and no thromboembolic events were reported, indicating a favorable short-term safety profile in clinical practice. These results are in line with Friedberg's cohort, where acne was the most common adverse event (22.9%),[12] and no serious complications were reported. Similarly, the Apulian network study described only 1 case of herpes zoster in an unvaccinated patient. Although the overall incidence of AEs was slightly higher in our cohort (57.5%), all were grade 1 and manageable, reinforcing the favorable short-term safety profile of upadacitinib in real-world use.

Upadacitinib, although belonging to the same JAK inhibitor class as tofacitinib, exhibits distinct pharmacologic properties as a selective JAK1 inhibitor.[22] In contrast, tofacitinib is a non-selective JAK1/3 inhibitor and has been associated with higher rates of AEs such as cardiovascular events, thromboembolism, herpes zoster, and malignancy,[23-25] prompting a boxed warning from the U.S. Food and Drug Administration. The ORAL Surveillance trial demonstrated increased risks of major adverse cardiovascular events and malignancy in the tofacitinib group compared to tumor necrosis factor inhibitors.[26] In contrast, upadacitinib's selectivity for JAK1 may reduce systemic immune suppression and off-target effects. Our findings, along with other real-world reports, did not identify any serious AEs, supporting the notion that upadacitinib may offer a more favorable and predictable safety profile in clinical practice.

Another clinically relevant issue is the impact of prior biologic experienced on treatment outcomes. In our study, there was no significant difference in clinical response or remission between biologic-naive and biologic-experienced patients. This finding aligns with previous studies, including the prospective cohort by Friedberg et al.,[12] in which 89.3% CD patients had failed at least 2 advanced therapies yet achieved high remission rates. Upadacitinib may therefore be a viable therapeutic option not only as a first-line advanced therapy but also in biologic-experienced or refractory patients.

In this study, 6 patients with CD underwent surgical intervention while receiving upadacitinib. This finding should not be interpreted as a lack of therapeutic efficacy but rather as a reflection of the chronic and structurally complicated nature of CD in these patients. Most surgical cases involved long-standing diseases with penetrating or stricturing behavior, where irreversible fibrotic or fistulizing changes had already developed before the initiation of upadacitinib. In such settings, medical therapy is often insufficient to reverse established structural damage, even when inflammatory activity is pharmacologically controlled. Notably, most of these patients demonstrated a decrease in CDAI scores prior to surgery, indicating partial symptomatic and inflammatory improvement under upadacitinib. However, surgery became inevitable due to fixed fibro-stenotic lesions or mechanical complications rather than uncontrolled inflammation. Furthermore, all 6 patients had previously failed multiple biologic agents, underscoring their refractory disease course. These findings emphasize that surgical intervention during upadacitinib treatment

does not necessarily represent drug failure, but rather highlights the importance of early, effective disease control before irreversible damage occurs.

This study has several limitations. As a single-center retrospective analysis with a limited sample size, its generalizability may be restricted. In addition, long-term follow-up and standardized endoscopic evaluations were not consistently available, limiting objective assessment of mucosal healing. While symptom-based endpoints reflect real-world clinical relevance, the absence of centralized adjudication may reduce measurement consistency. And follow-up PRO2 data were not available for all patients, potential bias due to missing data cannot be entirely excluded, although baseline characteristics were comparable between those with and without follow-up assessments. Nonetheless, the present study offers valuable insight into the early real-world performance of upadacitinib in Korean clinical practice, particularly given the paucity of data from Asian populations.

In conclusion, this single-center real-world study provides early evidence that upadacitinib is an effective and well-tolerated treatment option for Korean patients with moderate-to-severe UC and CD. Clinical remission and response were observed regardless of prior biological experience, and no serious AEs were reported. These findings support the practical utility of upadacitinib in routine IBD care. Further prospective, multicenter studies with longer follow-up are warranted to confirm its long-term efficacy and safety, particularly in Asian populations.

ADDITIONAL INFORMATION

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Conflict of Interest

Kim JE is an editorial board member of the journal but was not involved in the peer reviewer selection, evaluation, or decision process of this article. No other potential conflicts of interest relevant to this article were reported.

Data Availability Statement

The data underlying this article cannot be shared publicly, given the privacy expectations of the individuals who participated in the study. The data will be shared upon reasonable request to the corresponding author.

Author Contributions

Conceptualization: Kim JE, Hong SN. Data curation: Kim JE, Lee YC. Data interpretation: Kim JE. Formal analysis: Kim JE. Investigation: Hong SN. Methodology: Lee YC. Project administration: Hong SN. Resources: Kim JE. Software: Kim JE. Supervision: Hong SN. Validation: Kim M, Kim ER, Chang DK, Kim YH. Visualization: Lee YC. Writing–original draft: Kim JE. Writing–review & editing: Hong SN, Lee YC, Kim M, Kim ER, Kim YH, Chang DK. Approval of final manuscript: all authors.

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Supplementary Material

Supplementary materials are available at the Intestinal Research website (https://www.irjournal.org).

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