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The prolongation effect of ilaprazole-based standard triple therapy for *Helicobacter pylori*

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Abstract

Background: *Helicobacter pylori* (HP) infection causes many diseases, such as peptic ulcers, gastritis and gastric cancer, and MALToma. It has been gradually accepted that all HP-infected patients should be treated because HP is regarded as an infection. Therefore, the importance of selecting the optimal treatment regimen has increased. Although the 14-day standard triple therapy (STT) is recommended in the current guidelines, prolonging treatment duration is controversial in real practice because of inconsistent results from previous data and the risk of adverse effects. Additionally, the effect of STT using ilaprazole has not been reported until now. We aimed to compare the eradication rate between 7 and 10 days STT using ilaprazole.

Methods: A prospective randomized controlled trial was conducted, which was divided into 2 treatment groups: the control group was 7 days of STT, and the test group was 10 days of STT. The eradication regimen was 10 mg ilaprazole, 500 mg clarithromycin, and 1000 mg amoxicillin twice daily. We included patients who were diagnosed with positive results of *H pylori* examination. We compared the HP eradication rate according to treatment duration, CYP2C19 subtype and endoscopic diagnosis.

Results: We enrolled a total of 254 patients consisting of 127 patients in each treatment arm. The eradication rates of the control and test groups were 65.4% (82/127) and 74.8% (95/127), respectively, in the intention-to-treat analysis ($P = .1$). In the per-protocol analysis, 70.3% (83/118) and 82.6% (94/115) were eradicated in each group, which was statistically significant ($P = .027$). The CYP2C19 subtype was examined in 230 patients. The eradication rate was 79.2% (57/72), 75.4% (92/122), and 72.2% (26/36) in each group, which was not significantly different ($P = .704$).

Conclusion: Ten-day STT was more effective than 7-day STT for HP eradication. The eradication rate was not affected by the CYP2C19 genotype.

Abbreviations: HP = *Helicobacter pylori*, ITT = intention to treat, PP = per protocol, PPI = proton pump inhibitor, STT = standard triple therapy, UBT = urea breath test.

Keywords: CYP2C19, duration, *Helicobacter pylori*, ilaprazole, treatment

1. Introduction

Helicobacter pylori (HP) infection causes many diseases, such as peptic ulcers, gastritis and gastric cancer, and MALToma. It has been gradually accepted that all HP-infected patients should be treated because HP is regarded as infection.[1] Therefore, it is important to select an optimal treatment regimen as eradication is increasing. Standard triple therapy (STT), including the proton pump inhibitor amoxicillin and clarithromycin, is the most commonly prescribed regimen for HP eradication, although the eradication rate is decreasing. One method to increase the eradication rate is to prolong the treatment duration. The recent guidelines commented that prolongation of duration up to 14 days was more effective than 7 or 10 days.[1,2] However, prolonging treatment duration is controversial in real practices because of inconsistent results from previous data and the risk of adverse effects. Ilaprazole is a proton pump inhibitor that has a benzimidazole derivative. This drug is among the most recently

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developed proton pump inhibitors. It has the longest half-life, and its metabolism is not significantly influenced by CYP2C19.[3] The efficacy of ilaprazole in STT for HP eradication has not been studied until now. The aim of this study was to compare the HP eradication rate between 7 and 10 day STT using ilaprazole.

2. Materials and methods

2.1. Study population

In this multicenter prospective study, we included 20- to 80-year-old patients who were diagnosed with gastritis, peptic ulcers (including scars), or gastric neoplasms with documented *H pylori* infection. *H pylori* infection was confirmed by histology, rapid urease test, or 13C-urea breath test (UBT). Exclusion criteria included age under 20 years; allergy or hypersensitivity to the test drugs; pregnancy, breast feeding, childbearing age, and not using appropriate contraception; severe cardiovascular or pulmonary disease, uncontrolled diabetes mellitus (DM) or hypertension (HTN); drug or alcohol abuse; history of malignancy within the last 5 years (excluding those who underwent endoscopic curative resection for gastric dysplasia or early gastric cancer); history of surgery such as esophagectomy or gastrectomy; taking drugs such as sucralfate, prostaglandin analogue, anticholinergics, aspirin, NSAIDs, and steroids; diseases such as Zollinger Ellison syndrome, pancreatitis, absorption disorder, and Barrett esophagus, and hereditary diseases, such as galactose intolerance, lactase deficiency, and glucose-galactose malabsorption; and current participation in another clinical trial. Patients were recruited from the outpatient gastroenterology department in Daejeon St. Mary's Hospital, Konyang University Hospital and Eulji University Hospital, between January 2017 and March 2018. This study was approved by the Institutional Review Board of the Catholic University of Korea (IRB no. DC16MINV0093), Konyang University (IRB no.2016-11-005), Eulji University (IRB no. 2016-12-005), and registered at ClinicalTrials.gov (NCT03099876).

2.2. Study design

We enrolled patients who agreed to this protocol and provided informed consent. We randomly divided these patients into 7-day or 10-day eradication groups. The eradication regimens were ilaprazole 10 mg, amoxicillin 1000 mg, and clarithromycin 500 mg bid for 7 days or 10 days. The 10 and 20 mg tablets of ilaprazole are produced commercially. We defined 10 mg as the low dose. Randomization was performed using a computer-generated randomization table. This is a multicenter prospective clinical trial designed to evaluate the efficacy and safety of ilaprazole-based triple therapy as a first-line therapy for *H pylori* treatment. All subjects received ilaprazole (10 mg bid), clarithromycin (500 mg bid), and amoxicillin (1000 mg bid) for 7 or 10 days and understood that they were required to visit our laboratory or outpatient clinic following the study protocol. Four weeks after completion of eradication therapy, UBT was performed to assess eradication success. After completion of the eradication therapy, we assessed adverse events.

2.3. Confirmation of H pylori eradication

To perform UBT, patients swallowed ^{13}C-urea UBIT tablets (Otsuka Pharmaceutical Co., Ltd.) after baseline breath sampling. After 20 minutes, a second breath sample was obtained, and the $^{13}CO2/^{12}CO2$ ratio was determined with a paired sample with a POCone (Otsuka Electronics, Tokusima, Japan) device, which is an infrared spectral analyzer that measures the change in the carbon isotope ratio ($^{13}CO2/^{12}CO2$) in the exhaled air. The difference between the ratios before and after 13C-urea administration was expressed as $\Delta^{13}CO2$. The cut-off value was ≥2.5‰.

2.4. CYP2C19 genotyping

Blood sampling was performed to examine CYP2C19. Genomic DNA was extracted from peripheral blood by using the QIAamp DNA Mini Kit (Qiagen GmbH, Hilden, Germany). A genotyping study of the *CYP2C19* gene was performed by direct sequencing. The location of the c.681 G>A (rs4244285), c.636 G>A (rs4986893), and c.-806 C>T (rs12248560) single nucleotide variants resulting in CYP2C19*2, CYP2C19*3, and CYP2C19*17 in the *CYP2C19* gene were amplified by polymerase chain reaction (PCR) using different combinations of 3 primer sets designed using Primer3 (http://bioinfo.ut.ee/primer3/) by the authors. Direct sequencing of PCR products was performed using the BigDye Terminator v3.1 Cycle Sequencing Kit (Applied Biosystems, Foster City, CA), and the products were resolved on the ABI 3130XL Genetic Analyzer (Applied Biosystems). Sequence electropherograms were analyzed by using Sequencher 4.9 (Gene Codes, Ann Arbor, MI). The *CYP2C19* sequence with RefSeq ID NM_000769.4 was used as a reference for cDNA nucleotide numbering. All identified variants were confirmed by bidirectional resequencing.

The results were divided into 3 groups (homo extensive metabolizer, hetero extensive metabolizer, poor metabolizer).

2.5. Endoscopic diagnosis

We categorized the endoscopic diagnosis before HP eradication into 3 groups: gastritis, peptic ulcer (gastric and duodenal ulcer including ulcer scar), and gastric neoplasm (adenoma or early gastric cancer).

2.6. End points

The primary endpoint was the *H pylori* eradication rate of the 7-day and 10-day treatment periods. This was analyzed using intention to treat (ITT) and per protocol (PP) methods. The secondary endpoint was the eradication rate according to the CYP2C19 genotypes and endoscopic diagnosis in each treatment group.

2.7. Statistical analysis

The sample size was calculated based on a prior study.[4] We estimated the difference in the HP eradication rate of 7 and 10 days as 14%. The required number of patients was 254 in total and 127 in each group. We assumed a 5% level of significance with a power of 80% and a 17% dropout rate. R language version (R Foundation for Statistical Computing, Vienna, Austria) and T&F program ver. 2.9 (YooJin BioSoft, Korea) were used for all statistical analyses. Data were expressed as the mean ± SD for continuous variables, and the mean difference test between treatment groups was performed using Student *t* test. For categorical variables, data were expressed as sample number and percentage, N (%), and the chi-square test or Fisher exact test

was used to compare the eradiation rates between treatment groups or among diagnosis types. For comparison of the eradication rate among CYP2C19 genotypes, a linear by linear association test was used to test the linear trend of the eradication rate according to the CYP2C19 genotypes. When it was necessary to consider missing data, a 2-sample proportion test was used instead of the chi-square test, Fisher exact test, or linear by linear association test. Drop out data occurred randomly when the proportion test was used to analyze missing data in the treatment period, genotype, and diagnostic group.

3. Result

3.1. The baseline characteristics of enrolled patients

The baseline characteristics are described in Table 1. A total of 254 patients who were infected with *H pylori* were enrolled and randomized into 7-day and 10-day treatment groups. Each group consisted of 127 patients. In the 7-day treatment group, 9 patients were dropped because of withdrawal of agreement to participate, protocol violation, and adverse reactions. Twelve patients were dropped in the 10-day group because of withdrawal of agreement to participate, adverse reactions, and loss to follow-up. A total of 118 and 115 patients in the 7-day and 10-day groups completed the study protocol (Fig. 1).

The mean age of each group was 57.54 ± 11.11 in the 7-day group and 57.86 ± 11.15 in the 10-day group. Male patients were 58.3% and 60.6% in each group. BMI was 23.94 ± 2.86 and 24.4 ± 2.87 in each group. Social history, comorbidity, and diagnosis are summarized in Table 1. Other diseases in comorbidity were thyroid cancer, hepatitis, and 2 rectal cancers. There was no significant difference between the groups (Table 1).

3.2. Eradication rate of each treatment period

The eradication rates of the 7-day and 10-day treatments were 65.4% (83/127) and 74.8% (95/127) in the ITT analysis and 70.3% (83/118) and 82.6% (95/115) in the PP analysis, respectively. A higher eradication rate was observed in the 10-day treatment group in both analysis groups. However, the statistical significance was found in the per-protocol group ($P = .027$) (Tables 2 and 3).

3.3. Eradication rate according to CYP2C19 genotypes

Among 254 patients, 237 and 230 patients agreed to sample CYP2C19 in ITT and PP analyses. In the per-protocol analysis, the eradication rates of homo EM, hetero EM, and PM were 75.6% (31/41), 66.1% (37/56), and 71.4% (15/21), respectively, in the 7-day treatment group and 83.9% (26/31), 83.3% (55/66), and 73.3% (11/15), respectively, in the 10-day treatment group. A significant difference in eradication rate was not observed among the 3 different genotypes in the 7-day and 10-day treatment groups ($P = .593$ and .631) (Table 4).

Table 1

Baseline characteristics of variables.

Variable	Subgroup	N (%)	Group: 7 days	Group: 10 days	*P* value
Sample No (%)		254 (100)	127 (50)	127 (50)	
Age		254 (100)	57.54 ± 11.11	57.86 ± 11.15	.822
Sex		254 (100)			.701
	F	103 (40.6)	53 (41.7)	50 (39.4)	
	M	151 (59.4)	74 (58.3)	77 (60.6)	
BMI		254 (100)	23.94 ± 2.86	24.4 ± 2.87	.208
Alcohol		254 (100)			.663
	No	149 (58.7)	73 (57.5)	76 (59.8)	
	Yes	105 (41.3)	54 (42.5)	51 (40.2)	
Smoking		254 (100)			.449
	No	189 (74.4)	92 (72.4)	97 (76.4)	
	Yes	65 (25.6)	35 (27.6)	30 (23.6)	
Cardiovascular disease		254 (100)			.882
	No	195 (76.8)	98 (77.2)	97 (76.4)	
	Yes	59 (23.2)	29 (22.8)	30 (23.6)	
Diabetes mellitus		254 (100)			.229
	No	226 (89)	116 (91.3)	110 (86.6)	
	Yes	28 (11)	11 (8.7)	17 (13.4)	
Respiratory disease		254 (100)			1*
	No	245 (96.5)	123 (96.9)	122 (96.1)	
	Yes	9 (3.5)	4 (3.1)	5 (3.9)	
Other disease		254 (100)			.622*
	No	250 (98.4)	124 (97.6)	126 (99.2)	
	Yes	4 (1.6)	3 (2.4)	1 (0.8)	
Diagnosis		254 (100)			.954
	Gastritis	164 (64.6)	81 (63.8)	83 (65.4)	
	Ulcer	58 (22.8)	30 (23.6)	28 (22)	
	Neoplasm	32 (12.6)	16 (12.6)	16 (12.6)	

Continuous variables are expressed as mean ± SD. *P* value calculated using Student *t* test, categorical variables are expressed as sample number and %, *P* value calculated using Chi-squared test or Fisher exact test. SD = standard deviation.

* *P* value: calculated using Fisher exact test.

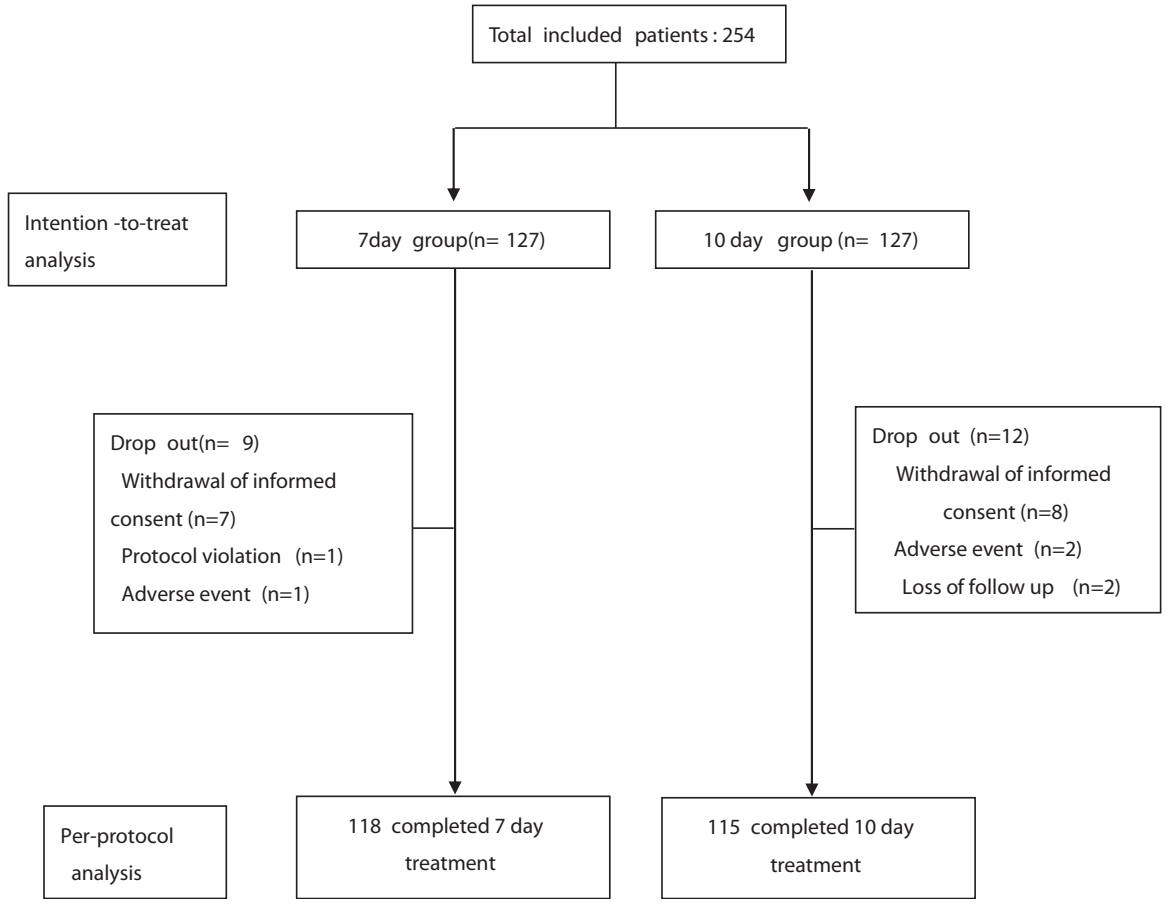

Figure 1. Enrollment flow diagram: the distribution of participants into 7- and 10-day treatment groups.

3.4. Eradication rate according to endoscopic diagnosis

In the per protocol analysis, the eradication of gastritis, peptic ulcers, and gastric neoplasm patients was 72.6% (53/73), 65.5% (19/29), 68.8% (11/16), respectively, in the 7-day treatment group and 80.8% (59/73), 92.6% (25/27), and 73.3% (11/15), respectively, in the 10-day treatment group. Statistical significance in eradication rate was not found among the endoscopic diagnoses in the 7-day and 10-day treatment groups ($P=.769$

Table 2

The eradication rates of the 7-day and 10-day treatment groups (intention-to-treat analysis).

Variable	Subgroup	N (%)	Group: 7 days	Group: 10 days	*P* value
Sample No (%)		254 (100)	127 (50)	127 (50)	
UBT	N	178 (70.1)	83 (65.4)	95 (74.8)	.1
	P	55 (21.7)	35 (27.6)	20 (15.7)	
	D	21 (8.3)	9 (7.1)	12 (9.4)	

Variables are expressed as sample number and %. D = drop out, N = negative, P = positive.
P value: calculated using 2 sample proportion test.

Table 3

The eradication rates of the 7-day and 10-day treatment groups (per-protocol analysis).

Variable	Subgroup	N (%)	Group: 7 days	Group: 10 days	*P* value	OR (95% CIs)
Sample No (%)		233 (100)	118 (50.6)	115 (49.4)		
UBT	N	178 (76.4)	83 (70.3)	95 (82.6)	.027*	1
	P	55 (23.6)	35 (29.7)	20 (17.4)		0.499 (0.268–0.931)

Variables are expressed as sample number and %.
OR: odds ratio and 95% confidence intervals calculated in the subsample of Group: 7 days versus 10 days. N = negative, P = positive.
P value: calculated using Chi-squared test.
* P value $< .05$.

Table 4

Differences in the eradication rate among the CYP2C19 genotypes stratified by treatment group (per-protocol analysis).

Group	Subgroup	N (%)	CYP2C19: Homo EM	CYP2C19: Hetero EM	CYP2C19: Poor M	*P* value	*P* value**
Total sample	UBT	230 (100)	72 (31.3)	122 (53)	36 (15.7)		
	N	175 (76.1)	57 (79.2)	92 (75.4)	26 (72.2)	.704	.404
	P	55 (23.9)	15 (20.8)	30 (24.6)	10 (27.8)		
7 days group	UBT	118 (100)	41 (34.7)	56 (47.5)	21 (17.8)		
	N	83 (70.3)	31 (75.6)	37 (66.1)	15 (71.4)	.593	.582
	P	35 (29.7)	10 (24.4)	19 (33.9)	6 (28.6)		
10 days group	UBT	112 (100)	31 (27.7)	66 (58.9)	15 (13.4)		
	N	92 (82.1)	26 (83.9)	55 (83.3)	11 (73.3)	.631*	.465
	P	20 (17.9)	5 (16.1)	11 (16.7)	4 (26.7)		

Variables are expressed as sample number and %. N = negative, P = positive.
P value: calculated using the chi-square test.
* *P* value: calculated using Fisher exact test.
** *P* value: calculated using linear by linear association test.

and .22). However, the eradication rate of peptic ulcer patients was significantly different between the 7-day (65.5% [19/29]) and 10-day (92.6% [25/27]) treatment groups ($P = .014$) (Tables 5 and 6).

3.5. Adverse events

The adverse events occurred in 4.7% (12/254), which was 3.1% (4/127) and 6.3% (8/127) in the 7-day and 10-day treatment groups, respectively. The adverse events were abdominal pain, chest pain, loose stool, bitter taste, and nausea. Serious adverse events did not occur. Adverse events tended to be more frequent in longer therapies, although there was no statistically significant difference ($P = .237$) (Table 7).

4. Discussion

Ilaprazole has been approved to treat peptic ulcer diseases and gastroesophageal reflux disease and *H pylori* eradication in South

Table 5

Differences in eradication rate among diagnosis types stratified by treatment group.

Group	Subgroup	N (%)	Gastritis	Ulcer	Neoplasm	*P* value	*P* value**
Total sample	UBT	233 (100)	146 (62.7)	56 (24)	31 (13.3)		
	N	178 (76.4)	112 (76.7)	44 (78.6)	22 (71)	.718	.718
	P	55 (23.6)	34 (23.3)	12 (21.4)	9 (29)		
7 days group	UBT	118 (100)	73 (61.9)	29 (24.6)	16 (13.6)		
	N	83 (70.3)	53 (72.6)	19 (65.5)	11 (68.8)	.769*	.77
	P	35 (29.7)	20 (27.4)	10 (34.5)	5 (31.2)		
10 days group	UBT	115 (100)	73 (63.5)	27 (23.5)	15 (13)		
	N	95 (82.6)	59 (80.8)	25 (92.6)	11 (73.3)	0.22*	0.231
	P	20 (17.4)	14 (19.2)	2 (7.4)	4 (26.7)		

Variables are expressed as sample number and %. N = negative, P = positive.
P value: calculated using the chi-square test.
* *P* value: calculated using Fisher exact test.
** *P* value: calculated using 2 sample proportion tests.

Table 6

Differences in the eradication rate between the treatment groups stratified by diagnosis type.

CYP2C19	Subgroup	N (%)	Group: 7 days	Group: 10 days	*P* value	OR (95% CIs)
Gastritis	UBT	146 (100)	73 (50)	73 (50)		
	N	112 (76.7)	53 (72.6)	59 (80.8)	.24	1
	P	34 (23.3)	20 (27.4)	14 (19.2)		0.629 (0.289–1.368)
Ulcer	UBT	56 (100)	29 (51.8)	27 (48.2)		
	N	44 (78.6)	19 (65.5)	25 (92.6)	.014*	1
	P	12 (21.4)	10 (34.5)	2 (7.4)		0.152 (0.03–0.777)
Neoplasm	UBT	31 (100)	16 (51.6)	15 (48.4)		
	N	22 (71)	11 (68.8)	11 (73.3)	>.99**	1
	P	9 (29)	5 (31.2)	4 (26.7)		0.8 (0.168–3.799)

Variables are expressed as sample number and %. N = negative, P = positive.
P value: calculated using chi-square test.
* *P* value < .05.
** *P* value: calculated using Fisher exact test.

Table 7

Distribution of adverse effects.

Variable	Subgroup	N (%)	Group: 7 days	Group: 10 days	*P* value
Adverse effect		254 (100)	127 (50)	127 (50)	.237
	No	242 (95.3)	123 (96.9)	119 (93.7)	
	Yes	12 (4.7)	4 (3.1)	8 (6.3)	
Diarrhea		1		1	
Chest pain		1	1		
Loose stool		1		1	
Bitter taste		4	2	2	
Gastroesophageal reflux		1		1	
Epigastric soreness		1		1	
Constipation		1		1	
Nausea		1		1	
Abdominal pain		1	1		

Adverse effect: expressed as sample number and %. *P* value calculated using Chi-squared test.

Korea. Ilaprazole provided a dose-dependent suppression of gastric acid secretion and showed similar safety relative to omeprazole.[5] The efficacy of ilaprazole in peptic ulcers and gastroesophageal reflux disease (GERD) has been reported in previous studies.[5–10]

There have been studies using ilaprazole for *H pylori* eradication. Liao et al[11] reported that 5 mg ilaprazole in quadruple and modified sequential therapy was effective. Ahn et al[12] reported that 10 mg ilaprazole in levofloxacin-based triple therapy yielded an 88.8% eradication rate. Kwack et al[13] reported that a high dose (80 mg per day) of ilaprazole with amoxicillin caused an eradication rate of approximately 80%. It was suboptimal for eradication rate compared with a previous study. However, no study was performed on the effect of eradication rate in standard triple therapy using ilaprazole. We evaluated the efficacy of the prolongation effect of ilaprazole-based STT for HP eradication in this study.

The STT is the most widely prescribed regimen for the 1st-line eradication of HP. However, the eradication rate of STT has a decreasing trend.[1,14,15] The reasons for treatment failure of STT are clarithromycin resistance, insufficient acid suppression, patient compliance, CYP2C19 genotype, treatment duration, and patient factors such as high body mass index and smoking.[16] In a meta-analysis study, the eradication rates of STT-7, STT-10, and STT-14 were 71.1% (68.3%–73.7%), 67.0% (60.0%–73.4%), and 76.4% (73.3%–79.2%), respectively, in the ITT analysis. The eradication rate of the STT-7, STT-10, and STT for 14 days was 78.5 (76.1%–80.8%), 78.4 (72%–83.6%), 85.2 (82.4%–87.7%) in the PP analysis.[14] In this study, the eradication rate of the 7-day treatment was lower than in the previous study, and the 10-day treatment was higher or belonged to a high level than previous studies. Therefore, we demonstrated the prolongation effect of ilaprazole based STT.

The methods of improving treatment efficacy are prolonging the treatment duration, changing the dosing and drug schedule of amoxicillin, using PPI not affected with CYP2C19 and high-dose PPI, addition of bisthmus.[17] Mastricht V guidelines and ACG guidelines are suggested for the 14-day treatment of STT.[1,2] However, the efficacy of STT is different among different regions of the country. It cannot be recommended for all patients in all countries. Indeed, there have been reports on the prolongation of the eradication treatment period in Korea. These studies did not show the benefit of extending the treatment duration of STT.[14,18,19] Our study showed a significantly higher eradication rate of 10-day STT compared with 7-day STT in the per-protocol analysis. Additionally, 10-day STT showed some improvement in the HP eradication rate in ITT analysis. Although the main therapeutic drugs of HP eradication are antibiotics, appropriate acid suppression is needed to enhance HP eradication because intragastric pH > 6 could change HP status from the stationary phase to the growth phase and can increase antibiotic stability and efficacy.[20] However, PPIs can reach the maximal effect after several days administration.[21] If the treatment duration is 7 days, the acid suppression effect can be suboptimal for HP eradication. Therefore, prolonging the treatment duration seems to be desirable.

The dose of PPI in HP eradication is usually the preferred high dose. However, we used low-dose ilaprazole for HP eradication because we planned to determine the efficacy of low-dose ilaprazole in HP eradication. Similarly, Mansour et al[22] showed that a half dose of rabeprazole-based STT was equally effective, inexpensive, and better tolerated than standard dose STT in HP eradication. In this study, low-dose ilaprazole-based STT also showed noninferior results of HP eradication in 10 days treatment group. This result may be related to the similar or better acid suppressing potency of 10 mg ilaprazole with other available proton pump inhibitors, such as intragastric pH > 4 holding time and mean 24 pH.[3]

One of the reasons why extending treatment duration was not effective in previous studies may be due to the variability of PPI effect by CYP2C19 polymorphism. Most PPIs are metabolized by the CYP2C19 pathway; therefore, CYP2C19 genotype differences can affect the eradication rate because of different PPI efficacies. Several studies regarding the eradication rate according to CYP2C19 have been reported. The results were inconsistent and different according to PPI.[23–26] Ilaprazole is known not to be affected by the CYP2C19 polymorphism because it is predominantly metabolized by CYP3A.[3] The effect of CYP2C19 on ilaprazole eradication was not demonstrated until now, and our results demonstrated that the CYP2C19 genotype did not affect the eradication rate in ilaprazole-based STT. Arévalo Galvis et al[27] reported that omeprazole-based personalized therapy according to the CYP2C19 genotype showed better results than conventional therapy and recommended high-dose PPI as an extensive metabolizer. El Rouby et al[28] also suggested precision medicine according to CYP2C19 genotype. However, genotyping in all HP-positive patients can be troublesome and is not cost effective. Therefore, using drugs

not related to CYP2C19 can be another option because an unpredictable response can be a drawback in the treatment of acid-related disease using PPI.

We enrolled HP-positive patients after endoscopic examination. The endoscopic diagnosis was gastritis, peptic ulcer, and gastric neoplasm. Our results showed that 10-day STT showed a higher eradication rate, especially in peptic ulcer patients. The results of previous studies were also similar in that peptic ulcer disease had a higher HP eradication rate than non-ulcer dyspepsia, and active ulcer was an independent predictor of successful eradication.[29–31] The reason might be that the degradation of the mucus and epithelial layers and altered vascular and epithelial permeability allowed better antibiotic penetration and better systemic delivery of drugs.

Our study has some strengths. First, we demonstrated the effect of prolongation of STT in HP eradication. Second, we demonstrated that the eradication rate using low-dose ilaprazole was comparable to other studies using standard PPI. Third, we demonstrated that the eradication rate is not affected by CYP2C19 status in ilaprazole-based STT.

There are limitations in this study. First, we did not conduct the clarithromycin-resistant test, which affected the eradication rate of STT. Second, the eradication rate of our study regimen was suboptimal. The optimal treatment regimen should be effective as an 80% eradication rate for ITT analysis and 90% for PP analysis.[32] Third, Missing data affected the eradication rate results between ITT and PP analysis in the treatment duration analysis group.

5. Conclusions

The 10-day STT was superior to the 7-day STT in this study. The eradication rate was not affected by the CYP2C19 genotype. Prolongation of STT using ilaprazole for 10 days can improve the *H pylori* eradication rate in Korean patients.

Author contributions

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