An Open-label Longitudinal Study on the Efficacy of Switching from Insulin Glargine or Detemir to Degludec in Type 2 Diabetes Mellitus

Ippei Kanazawa¹, Masakazu Notsu¹, Ken-ichiro Tanaka¹, Nobuaki Kiyohara¹,
Yuko Tada² and Toshitsugu Sugimoto¹

Abstract

Objective Insulin degludec (IDeg), a new long-acting basal insulin, and FlexTouch, a new injection device, recently became available in Japan. The efficacy and usefulness of IDeg and FlexTouch, compared with insulin glargine or detemir, were assessed in patients with type 2 diabetes mellitus.

Methods We performed an open-label longitudinal trial in 20 patients. After informed consent was obtained, all subjects recorded their self-monitoring data of the blood glucose (BG) level; thereafter, basal insulin was replaced by an IDeg-prefilled FlexTouch with the same dose and duration of time (2 weeks). After using FlexTouch, the patients were provided a device-specific questionnaire.

Results The patients were divided into two groups according to the dose of basal insulin (≥ 10 U and < 10 U). Although the mean fasting BG levels were unchanged, the mean BG levels before basal insulin injection and its standard deviation were significantly reduced after switching to IDeg in the patients receiving a higher dose of basal insulin (mean BG before basal insulin injection: 164 to 144 mg/dL, $p=0.002$; mean standard deviation: 32 to 22, $p=0.031$); however, this difference was not observed in the patients receiving a lower dose. The patients with a shorter duration of diabetes and a single injection of insulin preferred FlexTouch compared with conventional insulin devices.

Conclusion Replacing basal insulin with IDeg is useful for the stable and accurate control of blood glucose levels in type 2 diabetes for those receiving a higher dose of basal insulin. Furthermore, the patients with a shorter duration of diabetes and a single insulin injection preferred FlexTouch.

Key words: degludec, FlexTouch, type 2 diabetes mellitus

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Introduction

To prevent diabetic complications, rigorous glycemic control without fluctuation in the blood glucose (BG) level or hypoglycemia is crucial. Because the capacity of endogenous insulin secretion is decreased even in type 2 diabetes (1), basal insulin administration is important for achieving a stable and good control of daily BG for both type 1 and type 2 diabetes. Although the current long-acting insulin analogues have major advantages in their pharmacodynamic

profiles over neutral protamine Hagedorn, insulin glargine, and detemir, these analogues still exhibit a subtle peak effect, and some patients need to be injected twice daily to cover the basal insulin requirements (2). There are numerous patients with type 2 diabetes whose BG levels cannot be sufficiently controlled, even when using these basal insulin treatments, because of their unstable glucose profiles and hypoglycemia. Therefore, an improved long-acting insulin product was needed that could provide continuous, flat, and stable insulin replacement over an entire 24-h period with one daily injection.

¹Department of Internal Medicine 1, Shimane University Faculty of Medicine, Japan and ²Department of Internal Medicine, Matsue City Hospital, Japan

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Correspondence to Dr. Ippei Kanazawa, ippei.k@med.shimane-u.ac.jp

Figure 1. Study protocol. Basal insulin treatment was switched to insulin degludec for 2 weeks. In the week indicated by the asterisk, self-monitored blood glucose levels were recorded every day before breakfast and just before basal insulin injection.

Recently, insulin degludec (IDeg), a new, long-acting basal insulin preparation, has been made commercially available. IDeg is reported to have a terminal half-life of approximately 25 hours, which is two times longer than insulin glargine, and a duration of action of more than 42 hours (2, 3). In addition, IDeg provides a smaller peak effect compared with traditional basal insulin (4) and thus may be an ideal basal insulin to achieve the stable control of the BG levels.

As insulin devices have developed, it has become easier to initiate insulin therapy than before. It has become easier to teach diabetic patients how to use insulin injection pens; therefore, the use of these pens is widespread. Owing to continuous improvements in the injection-system technology, a prefilled injection device, FlexTouch, was newly generated by Novo Nordisk A/S (Kobenhavn, Denmark). It has been reported that more insulin-treated pen-naïve patients with type 1 and type 2 diabetes mellitus preferred FlexTouch in terms of the ease of use, insulin injection, diabetes management, and overall preference (5). In 2013, the IDeg-prefilled FlexTouch became available in Japan; however, the efficacy of IDeg or the usefulness of FlexTouch has not yet been clinically evaluated in patients with type 2 diabetes. We herein evaluate the BG levels and their fluctuations in Japanese patients with type 2 diabetes during the use of traditional basal insulin and IDeg and determine the usefulness of FlexTouch via interview forms when the previous injection device was switched to FlexTouch.

Materials and Methods

Subjects

Twenty participants with type 2 diabetes (mean age, 67.1 years; 65% men) were recruited in this open-label longitudinal study to evaluate the efficacy of IDeg compared with traditional basal insulin. At the study enrollment, the demographic data, clinical characteristics, and current diabetes treatments were recorded. The numbers of patients who had been taking sulfonylurea, metformin, dipeptidyl peptidase-4 inhibitors, and alpha-glucosidase inhibitors were 1, 4, 9, and 2, respectively. During the follow-up period, no prescribed medications except for basal insulin were changed, and no restrictions were imposed on the patients' lifestyle, except that they were encouraged to adhere to an appropriate weight-control program, including proper nutrition control

and regular exercise.

This study was in compliance with the Declaration of Helsinki and was approved by the Institutional Review Board of the Shimane University Faculty of Medicine. All subjects agreed to participate in the study and gave informed consent.

Study protocol

After informed consent was obtained, all subjects continued receiving insulin glargine or detemir once per day; thereafter, basal insulin was replaced by the same dose of IDeg for the same duration of treatment (2 weeks). The patients were requested to record their self-monitoring data of the fasting BG (FBG) before breakfast and the BG level just before injection of basal insulin (BG-I) for the week immediately prior to the switch to IDeg and for the second week after the switch to IDeg (Fig. 1). The means of the BG levels and standard deviation (SD) were calculated. The patients were also asked to record their symptoms when the glucose level was <70 mg/dL or when they noticed the signs of possible hypoglycemia.

Preference for pen devices

During the IDeg treatment, the patients switched their injection device to FlexTouch; however, the insulin regimen and needles remained the same. After using FlexTouch for 2 weeks, the patients were provided a device-specific questionnaire, which has been previously published (5). The questionnaire used assessed the subjects' preferences in terms of device convenience and ease of use in two parts. The first part was a device-specific questionnaire comprising 21 questions; the second part was a comparative device questionnaire comprising eight questions. The first part was assessed on an ordinal 5-point scale as the percentage in favor of FlexTouch, in favor of the previous device, or a similar preference for both devices. The overall preference was calculated based on the total points from the 21 questions. The responses on the second part were either in favor of FlexTouch, in favor of the previous device, or no preference for either device.

Statistical analysis

Data are expressed as the mean $\pm$ SD. The percent change of the BG level was calculated as follows: [(BG after IDeg - baseline BG)/baseline BG] $\times$ 100. Changes in the BG level and SD as well as the preference of device were examined

Table 1. Background Data of the Subjects.

Number of subjects (male/female)	20 (13/7)
Age (years)	67.1 ± 8.9
Duration of diabetes (years)	15.9 ± 10.7
Duration of insulin treatment (years)	7.3 ± 7.5
Preparation of basal insulin	
Glargine	16
Detemir	4
Dose of basal insulin (units)	12 ± 8
Basal and 3 mealtime rapid-acting insulin	12
Basal and 1 or 2 rapid-acting insulin	0
Basal without bolus insulin	8
BMI (kg/m ²)	25.3 ± 4.2
Grip power (kg)	28.9 ± 9.8
ALT (U/L)	24 ± 14
Serum creatinine (mg/dL)	0.82 ± 0.21
Mean of FBG (mg/dL)	134 ± 27
SD of FBG	17 ± 15
Mean of BG-I (mg/dL)	158 ± 48
SD of BG-I	28 ± 18
HbA1c (%)	7.3 ± 0.9

Data are mean ± SD.

BMI: body mass index, ALT: alanine aminotransferase, FBG: fasting blood glucose, SD: standard deviation, BG-I: blood glucose before injection of basal insulin, HbA1c: hemoglobin A1c

using the paired Student's *t*-test. Student's *t*-test and the χ^2 test were used in univariate analyses. All the analyses were performed using the statistical computer program StatView (Abacus Concepts, Berkeley, USA) and statistical significance was considered to exist at *p* value <0.05.

Results

Subjects' baseline characteristics

The baseline characteristics of the subjects are shown in Table 1. The number of the participants was 20 (13 men and 7 women), and the mean HbA1c was 7.3%. Sixteen patients received insulin glargine and four received insulin detemir. Four patients injected basal insulin before breakfast, one injected before dinner, and 15 injected before going to bed. Twelve patients received basal and three bolus mealtime rapid-acting insulin treatments; eight received basal insulin without bolus insulin. The mean dose of the basal insulin was 12 U per day. No patient experienced hypoglycemia during the course of this study.

Chronological changes in the BG parameters

Chronological changes in the BG levels and SDs of all the subjects are shown in Table 2. After switching from traditional basal insulin, the patients' mean BG-I and SD during IDeg treatment tended to be decreased, but the differences were not significant. The mean FBG and SD were unchanged. The mean BG-I of some of the patients decreased, while that of others was nearly the same or increased. Thus, we compared various parameters between the patients with a decreased and increased mean BG-I (Table 3). The dose and the ratio of basal insulin dose/body weight were marginally higher in the patients with a decreased BG-I than in those with an increased BG-I (*p*=0.053 and *p*=0.075, respectively).

The body mass index (BMI) in the patients with a decreased BG-I was significantly higher than in the patients with an increased BG-I (*p*=0.022). However, the other parameters did not differ. We therefore divided the patients into two groups according to the median dose of basal insulin (10 U) and evaluated the BG levels and SDs separately in each group. Although the glucose parameters remained unchanged in the patients in the lower basal insulin injection group (<10 U), the mean BG-I and SD were significantly decreased during IDeg treatment in the patients in the higher basal insulin injection group (≥10 U) (*p*=0.002 and *p*=0.031, respectively). These parameters were increased after the switch from IDeg to the previous basal insulin (Table 4). When the subjects were divided according to the ratio of basal insulin dose/body weight rather than basal insulin dose alone, similar results were observed (data not shown). Moreover, the percent changes were also significantly decreased in the IDeg treatment period and increased after switching to the previous insulin (Fig. 2). We then divided the subjects into two groups according to the median BMI (24.5 kg/m²). In contrast, no parameters changed in the higher and lower BMI groups (Table 5). In addition, the baseline BMI was not correlated with the changes in BG-I or SD (*p*=0.209 and *p*=0.878, respectively).

Preference of insulin injection device

Of the 21 device-specific questions, the preference scores of five questions were higher for FlexTouch compared with the previous devices, 11 were lower, and 5 were the same (Fig. 3). When the significance of device preference was examined using the Wilcoxon signed-rank test, the differences were not found to be significant. The overall preference also showed no difference between FlexTouch and the previous device. In the second part of the device-specific questionnaire, the preference scores of 5 questions were lower for FlexTouch than for the previous device, one was higher, and two were the same (Fig. 4).

According to the overall preference scores (Fig. 3), we divided the subjects into a FlexTouch preference group (*n*=9) and a previous device preference group (*n*=9) and compared the variables (Table 6). In the FlexTouch group, the duration of diabetes was significantly shorter than in the previous device group (*p*=0.034). Furthermore, the serum creatinine and mean FBG levels were significantly lower in the FlexTouch group than in the previous device group (*p*=0.035 and *p*=0.039, respectively). Moreover, the ratio of patients treated with basal insulin without bolus insulin treatment was significantly higher in the FlexTouch group (*p*=0.016). However, regardless of insulin device preference, the lowering effects on the BG levels were not different between the FlexTouch and previous device groups (8.2±24.0 vs. -2.0±17.7 mg/dL, *p*=0.319 for changes in FBG and -12.9±11.9 vs. 0.4±32.8 mg/dL, *p*=0.268 for changes in BG-I, respectively).

Table 2. Chronological Changes in the Parameters of Blood Glucose in All Subjects.

	Baseline	Degludec				After
			Mean change	95% CI	p	
Mean of FBG (mg/dL)	134 ± 27	135 ± 32	0.8	-9.4 - 10.9	0.879	133 ± 25
SD of FBG	17 ± 15	16 ± 10	-1.4	-6.4 - 3.6	0.566	18 ± 17
Mean of BG-I (mg/dL)	158 ± 48	150 ± 52	-7.7	-19.1 - 3.7	0.174	164 ± 65
SD of BG-I	28 ± 18	22 ± 13	-5.5	-11.7 - 0.7	0.078	26 ± 18

Data are mean ± SD.

FBG: fasting blood glucose, SD: standard deviation, BG-I: blood glucose before injection of basal insulin, CI: confidential interval

Statistical significance was determined using paired Student's *t* test compared to baseline data.

Table 3. Comparison of Various Parameters between Patients with Decreased BG-I and with Increased BG-I.

	Increased	Decreased	
Number of subjects	7	13	p
Age (years)	66.3 ± 7.3	67.5 ± 10.0	0.774
Duration of diabetes (years)	17.0 ± 13.4	15.4 ± 9.5	0.745
Duration of insulin treatment (years)	4.2 ± 4.3	9.0 ± 8.5	0.186
Dose of basal insulin (units)	7 ± 6	14 ± 8	0.053
Dose of basal insulin / body weight	0.12 ± 0.08	0.22 ± 0.13	0.075
Basal with 3 bolus/basal without bolus	3/4	5/8	0.783
BMI (kg/m ²)	22.5 ± 3.2	26.9 ± 3.9	0.022
Grip power (kg)	34.3 ± 9.4	26.8 ± 9.5	0.156
ALT (U/L)	20 ± 8	26 ± 16	0.400
Serum creatinine (mg/dL)	0.81 ± 0.23	0.82 ± 0.20	0.974
Mean FBG (mg/dL)	132 ± 22	135 ± 30	0.850
SD of FBG	14 ± 8	19 ± 18	0.539
Mean of BG-I (mg/dL)	150 ± 54	162 ± 47	0.613
SD of BG-I	26 ± 20	29 ± 18	0.813
HbA1c (%)	7.2 ± 0.8	7.3 ± 0.9	0.839

Data are mean ± SD.

BMI: body mass index, ALT: alanine aminotransferase, FBG: fasting blood glucose, SD: standard deviation, BG-I: blood glucose before injection of basal insulin, HbA1c: hemoglobin A1c

Table 4. Chronological Changes in the Parameters of Blood Glucose in Patients Treated with Less than or More than 10 Units of Basal Insulin.

Dose of basal insulin < 10 units (n=9)						
	Baseline	Degludec				After
			Mean change	95% CI	p	
Mean of FBG (mg/dL)	123 ± 24	124 ± 26	1.0	-9.3 - 11.3	0.828	122 ± 23
SD of FBG	11 ± 7	12 ± 9	1.2	-1.3 - 3.7	0.295	14 ± 15
Mean of BG-I (mg/dL)	150 ± 54	157 ± 66	6.9	-13.0 - 26.7	0.446	151 ± 73
SD of BG-I	22 ± 19	23 ± 17	0.4	-7.5 - 8.4	0.901	18 ± 15
Dose of basal insulin ≥ 10 units (n=11)						
	Baseline	Degludec				After
			Mean change	95% CI	p	
Mean of FBG (mg/dL)	143 ± 27	143 ± 34	0.5	-17.9 - 19.0	0.949	143 ± 28
SD of FBG	22 ± 18	18 ± 10	-3.5	-13.0 - 5.9	0.423	22 ± 14
Mean of BG-I (mg/dL)	164 ± 45	144 ± 40	-19.6	-30.2 - 9.0	0.002	158 ± 45
SD of BG-I	32 ± 17	22 ± 10	-10.4	-19.5 - 1.2	0.031	32 ± 16

Data are mean ± SD.

FBG: fasting blood glucose, SD: standard deviation, BG-I: blood glucose before injection of basal insulin, CI: confidential interval

Statistical significance was determined using paired Student's *t* test compared to baseline data.

Discussion

In this study, neither parameter was significantly changed

after switching to IDeg when the glucose levels and SDs were examined in all the subjects. These findings suggest that switching from traditional basal insulin to IDeg may not be useful for all patients with type 2 diabetes. However,

Figure 2. Percent changes in the blood glucose parameters before basal insulin injection. The subjects were divided into two groups according to the dose of basal insulin (≥ 10 U and < 10 U). Percent changes in the blood glucose before BG-I and its SD were significantly decreased during the insulin degludec treatment. After the switchover to the previous basal insulin, the BG levels returned to the baseline levels. BG-I: basal insulin injection, SD: standard deviation

Table 5. Chronological Changes in the Parameters of Blood Glucose in Patients Treated with Less than or More than 24.5 kg/m² of Body Mass Index.

BMI < 24.5 kg/m ² (n=9)						
	Baseline	Degludec				After
			Mean change	95% CI	p	
Mean of FBG (mg/dL)	134 ± 24	138 ± 29	3.8	-18.5 - 26.0	0.706	135 ± 24
SD of FBG	20 ± 21	17 ± 12	-2.9	-12.1 - 6.4	0.492	22 ± 19
Mean of BG-I (mg/dL)	159 ± 60	154 ± 69	-5.1	-29.0 - 18.8	0.635	159 ± 78
SD of BG-I	30 ± 23	24 ± 17	-6.3	-18.3 - 5.6	0.256	25 ± 19
BMI ≥ 24.5 kg/m ² (n=11)						
	Baseline	Degludec				After
			Mean change	95% CI	p	
Mean of FBG (mg/dL)	134 ± 30	132 ± 35	-1.7	-11.6 - 8.1	0.704	132 ± 31
SD of FBG	15 ± 8	15 ± 7	-0.2	-6.9 - 6.5	0.953	16 ± 10
Mean of BG-I (mg/dL)	157 ± 40	147 ± 36	-9.8	-22.3 - 2.7	0.111	151 ± 38
SD of BG-I	26 ± 14	21 ± 10	-4.8	-12.7 - 3.0	0.201	27 ± 15

Data are mean ± SD.

BMI: body mass index, FBG: fasting blood glucose, SD: standard deviation, BG-I: blood glucose before injection of basal insulin, CI: confidential interval

Statistical significance was determined using paired Student's *t* test compared to baseline data.

BG-I and SD were significantly decreased during IDeg treatment in the patients receiving a higher dose (more than 10 U) of basal insulin. Moreover, these parameters increased to their baseline levels after switching to the previous basal insulin. These findings suggest that switching from basal insulin to IDeg was beneficial in the patients receiving treatment with a high dose of basal insulin.

We speculated that IDeg treatment decreased BG-I compared with the treatment with traditional basal insulin because IDeg is an ultra-long-acting basal insulin (4). However, BG-I remained unchanged when the subjects were restricted to the use of less than 10 U of basal insulin. One possibility may be that residual insulin secretion remained in the patients receiving a lower dose of basal insulin compared with the higher dose users. Therefore, BG-I was not increased in these patients even though the effect of tradi-

tional basal insulin gradually decreased until the time of the basal insulin injection. In contrast, the patients whose residual insulin secretion was already reduced needed a high dose of basal insulin; thus, IDeg was more effective for those patients. It has been previously reported that IDeg more effectively reduced the glucose levels and increased the hypoglycemia events than insulin glargine in the patients with type 1 diabetes when insulin glargine was switched to the same dose of IDeg (6). However, the parameters of residual insulin secretion were not examined in this previous study. Another possibility is that the evaluation period was too short to examine the effect of low-dose IDeg on the BG levels. The initial day of blood monitoring was after using IDeg for 1 week. Several days are generally needed for a stable glucose-lowering effect of IDeg. Further longitudinal studies are thus necessary to investigate the relationship be-

Figure 3. The subjects' comparison assessments via a device-specific questionnaire on FlexTouch and the previously used device. The black bars indicate the number of subjects rating FlexTouch with the higher score; gray bars indicate the number of subjects rating the other device with the higher score; and white bars indicate the number of subjects who gave both the devices the same rating.

Figure 4. The subjects' comparison assessments via a device-specific comparative preference questionnaire on FlexTouch and the previously used device. The black bars indicate the number of subjects rating FlexTouch with the higher score; gray bars indicate the number of subjects rating the other device with the higher score; and white bars indicate the number of subjects who gave a similar rating for both devices.

tween the effect of IDeg and the residual capacity of insulin secretion as well as the dose of basal insulin in type 2 diabetes.

Conversely, the FBG levels remained unchanged after the

switch to IDeg. Phase 2 and 3 trials have shown similar results to the present study. The lowering effects of IDeg and glargine on the FBG and HbA1c levels were not different in the patients with type 2 diabetes (7, 8). However, it has

Table 6. Comparison of Various Parameters between the Preference of Insulin Device.

	FlexTouch	Previous Pen	
Number of subjects	9	9	p
Age (years)	65.4 ± 9.8	67.2 ± 7.6	0.674
Male/female	7 / 2	6 / 3	0.599
Duration of diabetes (years)	10.3 ± 7.5	21.2 ± 11.9	0.034
Duration of insulin treatment (years)	4.6 ± 5.6	10.2 ± 8.9	0.140
Dose of basal insulin (units)	13 ± 10	10 ± 6	0.490
Basal with 3 bolus/basal without bolus	3 / 6	8 / 1	0.016
BMI (kg/m ²)	25.9 ± 3.7	24.9 ± 5.3	0.648
Grip power (kg)	31.6 ± 8.2	29.1 ± 10.7	0.611
Mean FBG (mg/dL)	123 ± 27	149 ± 22	0.039
SD of FBG	13 ± 8	23 ± 20	0.198
Mean of BG-I (mg/dL)	151 ± 48	173 ± 50	0.352
SD of BG-I	25 ± 15	34 ± 20	0.308
HbA1c (%)	7.2 ± 1.0	7.5 ± 0.8	0.446
Changes in mean FBG (mg/dL)	8 ± 24	-2 ± 18	0.319
Changes in SD of FBG	0 ± 9	-3 ± 14	0.588
Changes in mean of BG-I (mg/dL)	-13 ± 12	0 ± 33	0.268
Changes in SD of BG-I	-4 ± 10	-8 ± 17	0.633

Data are mean ± SD.

BMI: body mass index, ALT: alanine aminotransferase, FBG: fasting blood glucose, SD: standard deviation, BG-I: blood glucose before injection of basal insulin, HbA1c: hemoglobin A1c

been previously reported that the events of nocturnal hypoglycemia were significantly reduced in the patients treated with IDeg compared with those treated with insulin glargine (8). The glucose-lowering effects of insulin glargine and detemir last a maximum of approximately 4 and 7 hours, respectively, after injection and then decrease gradually (9). The peak effects of glargine and detemir may cause nocturnal hypoglycemia. In contrast, the glucose-lowering effects of IDeg are reported to be flat and stable over 24 hours when measured by the euglycemic glucose clamp method (4). Therefore, switching from conventional basal insulin to IDeg may be beneficial even if the FBG and HbA1c levels do not change. Because no hypoglycemic events were reported in the present short-term study of relatively poorly controlled patients, further studies are needed to examine this point in the future.

The stability effect of IDeg is clinically useful for controlling daily BG levels. If a patient's BG levels are constantly fluctuating, it is difficult to change the insulin administration dose. In contrast, adjusting the insulin dose becomes easier if the BG levels are stabilized. Previous studies have shown that the BG fluctuation improved after replacing insulin glargine with IDeg (10). As described previously, the stability of IDeg's action leads to a stable BG. In the present study, the SD value of BG-I was significantly decreased after switching from basal insulin to IDeg in the patients treated with a higher dose; thereafter, it returned to the baseline level. Therefore, these findings confirm the stable glucose-lowering effect of IDeg in the patients with type 2 diabetes.

Previous studies demonstrated that FlexTouch accurately and consistently delivered insulin (11). Moreover, FlexTouch is currently the only prefilled pen that has a push button that does not extend at any dose (as opposed to the traditional

prefilled pens which require more thumb or finger pressure for injection). This may make it easier for patients to inject insulin. In the present study, we evaluated the preference for FlexTouch when the insulin device was exchanged for 2 weeks. Half of the patients preferred FlexTouch compared with the previous device they used and half did not. In addition, the patients with a shorter duration of diabetes, single insulin injection, and lower FBG levels tended to prefer FlexTouch compared with their previous insulin device. In other words, the patients with a longer duration of diabetes receiving basal and three bolus mealtime rapid-acting insulin treatments may have become more accustomed to the insulin device they were using. However, the insulin device preference made no difference in the glucose-lowering effect of IDeg.

There are some limitations associated with the present study. First, the sample size was not large enough to make definite conclusions. A large-scale study ought to be conducted to confirm the present findings. However, we chronologically evaluated the BG levels and SDs after switching from IDeg to the previous insulin and found that the parameters evaluated returned to the baseline levels. These findings support the effectiveness of IDeg. Second, we analyzed only subjects who accepted the study protocol; therefore, we are not able to exclude potential selection bias. Third, due to the limited number of subjects, we could not separately assess insulin glargine and detemir. Fourth, the BMIs in the present populations were lower than those observed in Western populations, and the capacity of insulin secretion and degree of obesity in Asian populations are known to differ from Western populations (12). Thus, large-scale longitudinal studies should be performed in other countries. In contrast, previous studies showed no differences in the BG levels between IDeg and glargine (7, 8).

We found that the BG-lowering effects of high-dose IDeg may be more favorable than traditional basal insulin. The contradictory results between the previous studies and the present study may be due to the differences in the study protocol, basal insulin doses, and insulin injection devices.

In conclusion, replacing basal insulin with IDeg is useful for the stable and accurate control of the BG levels in the patients with type 2 diabetes receiving higher doses of basal insulin. The patients with a short duration of diabetes receiving a single injection of insulin preferred switching from their device to FlexTouch.

This manuscript has been registered with an approved IC-MJE clinical trial registry ID (UMIN000011333).

The authors state that they have no Conflict of Interest (COI).

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