



**510(k) SUBSTANTIAL EQUIVALENCE DETERMINATION
DECISION SUMMARY
INSTRUMENT ONLY**

I Background Information:

A 510(k) Number

K200467

B Applicant

Tandem Diabetes Care, Inc.

C Proprietary and Established Names

Control-IQ Technology

D Regulatory Information

Product Code(s)	Classification	Regulation Section	Panel
QJI	Class II	21 CFR 862.1356 - Interoperable Automated Glycemic Controller	CH - Clinical Chemistry

II Submission/Device Overview:

A Purpose for Submission:

Modification to a cleared device to expand the age indication (from ≥ 14 years old to ≥ 6 years old).

B Type of Test:

Not applicable

III Intended Use/Indications for Use:

A Intended Use(s):

See Indications for Use below.

B Indication(s) for Use:

Control-IQ technology is intended for use with compatible integrated continuous glucose monitors (iCGM) and alternate controller enabled (ACE) pumps to automatically increase, decrease, and suspend delivery of basal insulin based on iCGM readings and predicted glucose values. It can also deliver correction boluses when the glucose value is predicted to exceed a predefined threshold.

Control-IQ technology is intended for the management of Type 1 diabetes mellitus in persons 6 years of age and greater.

Control-IQ technology is intended for single patient use and requires a prescription.

Control-IQ technology is indicated for use with NovoLog or Humalog U-100 insulin.

C Special Conditions for Use Statement(s):

Rx - For Prescription Use Only

Only use U-100 Humalog or U-100 NovoLog with your pump. Only U-100 Humalog and NovoLog have been tested and found to be compatible for use in the pump. Use of insulin with lesser or greater concentration can result in under delivery or over delivery of insulin. This can cause hypoglycemia (low BG) or hyperglycemia (high BG) events.

When the CGM reading is automatically populated into the bolus calculator, only the current CGM reading is used to calculate the correction bolus. The trend arrow is not used in the dose calculation. Speak with your healthcare provider for recommendations on how best to utilize the arrows for your correction bolus dosing.

Control-IQ technology should not be used in anyone under the age of six years old. Control-IQ technology should also not be used in patients who require less than a total daily insulin dose of 10 units per day or who weigh less than 55 pounds, as those are the required minimum values needed in order for Control-IQ technology to operate safely.

At the time of device authorization, compatible iCGMs include the following: Dexcom G6 iCGM

The t:slim X2 pump, transmitter, and sensor must be removed before Magnetic Resonance Imaging (MRI), Computed Tomography (CT) scan, or diathermy treatment. Exposure to MRI, CT, or diathermy treatment can damage the components.

DO NOT use Control-IQ technology if you are taking hydroxyurea, a medication used in the treatment of diseases including cancer and sickle cell anemia. Your Dexcom G6 CGM readings may be falsely elevated and result in over-delivery of insulin that could result in severe hypoglycemia.

IV Device/System Characteristics:

A Device Description:

Control-IQ technology (Control-IQ, the device) is a software-only device intended for use by people with diabetes. The device controls insulin delivery from a compatible alternate controller enabled insulin pump (ACE pump) based on inputs provided by a compatible integrated continuous glucose monitor (iCGM) and inputs provided the user (e.g., carbohydrate intake, exercise, and sleep schedule). Control-IQ technology is meant to be installed on a compatible ACE pump.

Control-IQ technology works to control glucose towards a glucose target range of 112.5-160 mg/dL during normal use. Glucose targets are not customizable but can be changed by a user if sleep or exercise modes are set or announced. During sleep mode, this range is changed to 112.5-120 mg/dL, and it is changed to 140-160 mg/dL during exercise mode.

Control-IQ technology includes an integrated feature whereby iCGM values are automatically populated into the glucose field of the integrated bolus calculator when the Control-IQ technology is active (i.e., the device is operating in closed-loop mode). This feature is disabled when Control-IQ is turned off.

Using Control-IQ technology requires that users input their weight and their total daily insulin requirement, which should be established with the help of a health care provider before using the device.

Instrument Description Information:

1. Instrument Name:

Control-IQ technology

2. Specimen Identification:

N/A

3. Specimen Sampling and Handling:

N/A

4. Calibration:

N/A

5. Quality Control:

N/A

V Substantial Equivalence Information:

A Predicate Device Name(s):

Control-IQ Technology

B Predicate 510(k) Number(s):

DEN190034

C Comparison with Predicate(s):

Device & Predicate Device(s):	<u>K200467</u>	<u>DEN190034</u>
Device Trade Name	Control-IQ technology	Control-IQ technology
General Device Characteristic Similarities		
Intended Use/Indications For Use	Same	For use with compatible integrated continuous glucose monitors (iCGM) and alternate controller enabled (ACE) pumps to automatically increase, decrease, and suspend delivery of basal insulin based on iCGM readings and predicted glucose values. It can also deliver correction boluses when the glucose value is predicted to exceed a predefined threshold.
General Device Characteristic Differences		
Intended User Population	Persons age ≥ 6 years with Type 1 diabetes mellitus	Persons age ≥ 14 years with Type 1 diabetes mellitus

VI Standards/Guidance Documents Referenced:

Special controls established under 21 CFR 862.1356.

ISO 14971:2007: Medical Devices - Application of Risk Management to Medical Devices FDA Recognition No: 5-40

VII Performance Characteristics (if/when applicable):

A Analytical Performance:

Control-IQ technology was previously granted marketing authorization under DEN190034. The version of Control-IQ technology described in this submission is identical to the predicate version, with the exception of an expanded intended use population. No modifications were made to the device in order to accommodate this change.

B Other Supportive Instrument Performance Characteristics Data:

Summary of Clinical Testing:

The sponsor conducted a prospective, multi-center, randomized controlled study to compare the use of Control-IQ technology (or Closed Loop Control, CLC) to the use of sensor-augmented pump (SAP). The randomized controlled phase (Primary Study) was 4 months in duration, followed by an Extension Phase of 3 months where all subjects were using the CLC.

A summary of the pivotal clinical study is provided in the following table (Control-IQ group abbreviated as CLC (closed-loop control)):

Study Feature	Description
Title	The International Diabetes Closed Loop (iDCL) Trial: Clinical Acceptance of the Artificial Pancreas in Pediatrics
Summary	A randomized controlled trial of 4 month at home closed loop control (CLC) system vs. sensor-augmented pump (SAP).
Investigational Device	Control-IQ Technology
Objectives	The objective of the study is to assess efficacy and safety of a closed loop system (Control-IQ Technology) in pediatrics in a randomized controlled trial.
Study Design	Randomized Clinical Trial with 3:1 randomization to intervention with the closed loop system vs. sensor-augmented pump for 3 months.
Number of Sites	Four US clinical sites

Study Feature	Description
Population	<p>There were 29 subjects ages ≥ 6 to ≤ 9 years old, and 72 subjects ages > 9 to ≤ 13 years old. The average baseline HbA1c was 7.6% for the intervention arm and 7.9% for the control arm.</p> <p>Key Inclusion Criteria</p> <ul style="list-style-type: none"> • Type 1 diabetes for at least 1 year • Using insulin for at least 1 year • Age ≥ 6 to ≤ 13 years old • Weight 25-140 kg • Total daily insulin dose of at least 10 U/day <p>Key Exclusion Criteria</p> <ul style="list-style-type: none"> • Use of any non-insulin glucose-lowering agents other than metformin
Sample Size	101 participants completed the 4-month randomized trial, with 78 in the intervention arm and 23 in the control arm.
Treatment Groups	<p>Randomized Trial</p> <ul style="list-style-type: none"> • Intervention Group: t:slim X2 with Control-IQ Technology and Dexcom G6 iCGM. • Control Group: Sensor-augmented pump (SAP) with no automated insulin delivery, and Dexcom G6 iCGM.
Study Duration	4 months for primary study, and up to 7 months total with extension phase
Protocol Overview/Synopsis	Eligible participants not currently using an insulin pump and/or Dexcom G4, G5, or G6 CGM with minimum data requirements participated in a run-in phase of 2 to 8 weeks that was customized based on whether the participant was already a pump or CGM user. Participants who skip or successfully complete the run-in were randomly assigned 3:1 to the CLC group using t:slim X2 with Control-IQ Technology or the SAP group for 4 months.

Primary Study Safety Results

No severe hypoglycemia or diabetic ketoacidosis (DKA) events occurred in either arm of the study.

Hyperglycemia / ketosis events not meeting the definition of DKA were reportable if they met one of the following criteria:

- evaluation or treatment was obtained at a health care provider facility for an acute event involving hyperglycemia or ketosis

- blood ketone level ≥ 1.0 mmol/L and communication occurred with a health care provider at the time of the event
- blood ketone level ≥ 3.0 mmol/L, even if there was no communication with a health care provider

There were 7 hyperglycemia/ketosis events meeting the above reporting criteria in the CLC arm compared to 2 in the SAP arm.

Subjects in both study arms were provided with blood ketone meters for use at home. There were 10 recorded events of blood ketone levels > 1.0 mmol/L in the CLC arm compared to 6 recorded events in the SAP arm.

A summary of all reportable adverse events observed during the study is provided in the following table:

Table 1: Adverse Events by Study Treatment Group

	CLC	SAP
Hyperglycemia with or without ketosis	7	2
Diabetic Ketoacidosis (DKA)	-	-
Ketosis due to illness	-	1
Total:	7	3

The sponsor performed an evaluation of the Control-IQ technology and determined that it may not be safe for use in children under the age of six because Control-IQ technology has lower limits of total daily insulin (≥ 10 units) and weight requirements (≥ 55 lbs.). Therefore, the sponsor has included a warning in the labeling for this device as follows:

“Tandem performed an evaluation of the Control-IQ technology and determined that it may not be safe for use in children under the age of six because Control-IQ technology has lower limits of total daily insulin and weight requirements. Therefore, Control-IQ technology should not be used in anyone under the age of six years old. Control-IQ technology should also not be used in patients who require less than a total daily insulin dose of 10 units per day or who weigh less than 55 pounds, as those are the required minimum values needed in order for Control-IQ technology to operate safely.”

Primary Study Observed Results

The data below describe how the device performed during the primary study.

The table below provides a summary of selected metrics for the study run-in period (baseline), and the results after study completion (post randomization).

Table 2: Available CGM readings, HbA1c, and mean glucose observed in the primary study

	Baseline		Post Randomization	
	CLC (n=77*)	SAP (n=23)	CLC (n=78)	SAP (n=22*)
Hours of glucose readings, Mean ± SD	306 ± 33	311 ± 23	2637 ± 134	2609 ± 128
HbA1c, Mean ± SD	7.6 ± 1.0	7.9 ± 0.9	7.0 ± 0.8	7.6 ± 0.9
Mean CGM Glucose (mg/dL), Mean ± SD	184 ± 33	189 ± 34	162 ± 18	179 ± 26

*One participant in the CLC group was missing baseline CGM data; one participant in the SAP group was missing follow-up data.

During the pivotal study, the amount of time subjects spent in different CGM glucose ranges was observed as described in the following tables:

Table 3: Time spent in different CGM glucose ranges as observed in the primary study

	Baseline		Post Randomization	
	CLC (n=77*)	SAP (n=23)	CLC (n=78)	SAP (n=22*)
% time in range 70-180 mg/dL, Mean ± SD	53 ± 17	51 ± 16	67 ± 10	55 ± 13
% time below 70 mg/dL, Mean ± SD	1.92 ± 2.21	1.52 ± 1.52	1.80 ± 1.38	2.10 ± 1.18
% time below 54 mg/dL, Mean ± SD	0.33 ± 0.54	0.19 ± 0.28	0.34 ± 0.35	0.38 ± 0.35

*One participant in the CLC group was missing baseline CGM data; one participant in the SAP group was missing follow-up data.

Table 4: Time spent in different CGM glucose ranges analyzed by time of day, post-randomization

	Daytime		Nighttime	
	CLC (n=77*)	SAP (n=23)	CLC (n=78)	SAP (n=22*)
Mean CGM Glucose (mg/dL), Mean ± SD	167 ± 21	179 ± 27	146 ± 16	180 ± 28
% time above 180 mg/dL, Mean ± SD	35 ± 11	42 ± 15	19 ± 9	44 ± 16
% time 70-180 mg/dL, Mean ± SD	63 ± 11	56 ± 14	80 ± 9	54 ± 16
% time below 70 mg/dL, Median (Q1, Q3)**	1.55 (0.77, 2.76)	1.78 (1.31, 3.34)	0.91 (0.44, 1.82)	1.33 (0.59, 2.68)

*One participant in the CLC group was missing baseline CGM data; one participant in the SAP group was missing follow-up data.

**Quartile 1, Quartile 3

Extension Phase

The primary study was followed by a 3-month single-arm extension phase. Of the 101 subjects enrolled in the primary study, 100 subjects continued into the extension phase. During the extension phase, subjects who were originally randomized to the control (SAP) arm of the primary study were switched to use of the investigational Control-IQ device (CLC arm) such that all subjects were in the CLC study arm for the extension phase.

Extension Phase Safety Results

There were an additional eight (8) device related hyperglycemia / ketosis events during the extension phase, and no episodes of DKA or severe hypoglycemia.

Extension Phase Observed Results

Results observed in the extension phase were similar to results observed during the primary study. Those subjects originally randomized into the CLC arm maintained similar results during the extension phase. Results for subjects originally randomized in the SAP arm who switched to the CLC arm are summarized in the table below:

Table 5: Available CGM readings, HbA1c, mean glucose, and time spent in different CGM glucose ranges observed in the study extension phase

	Extension Baseline*	Weeks 17-28
	SAP – CLC Group (n=22)	SAP – CLC Group (n=22)
Hours of glucose readings, Mean ± SD	1885 ± 88	1981 ± 86
HbA1c, Mean ± SD	7.6 ± 0.9	7.3 ± 0.6
Mean CGM Glucose (mg/dL), Mean ± SD	179 ± 26	167 ± 18
% time in range 70-180 mg/dL, Mean ± SD	55 ± 14	65 ± 10
% time above 180 mg/dL, Mean ± SD	43 ± 14	34 ± 10
% time below 70 mg/dL, Median (Q1, Q3)**	1.88 (1.12, 2.94)	1.34 (0.92, 1.95)

*Extension baseline is defined as the last 12 weeks of the primary study.

**Quartile 1, Quartile 3

Postmarket Surveillance Study:

There is uncertainty remaining regarding the risk/benefit profile of the device when used in the broader intended use population. While the premarket clinical study provided to support this premarket notification showed some benefits, the study included device users and their caregivers with relatively high levels of education relative to the general use population, and it was not adequately powered to assess differences in the rates of safety events (e.g., diabetic ketoacidosis and severe hypoglycemia). Furthermore, due to the nature of the study design, the apparent unfavorable difference in the rates of hyperglycemia/ketosis events (not rising to the level of severity of diabetic ketoacidosis) between the treatment and control arms may be due to reporting differences between users rather than a true difference from the device itself.

Accordingly, the existing postmarket surveillance study that was ordered for the Control-IQ device (PS190006, order dated December 13, 2019) will be expanded to include subjects ages 6-13 years old and to increase the total enrollment in the study to allow for inclusion of this additional cohort.

Summary of Human Factors Testing for the Expanded Age Range:

As established in DEN190034. The summative human factors study conducted under DEN190034 included assessment of the 6-13 year pediatric age group, and the results were found to be acceptable.

VIII Proposed Labeling:

The labeling supports the finding of substantial equivalence for this device.

IX Conclusion:

The submitted information in this premarket notification is complete and supports a substantial equivalence decision.