510(k) SUBSTANTIAL EQUIVALENCE DETERMINATION
DECISION SUMMARY
ASSAY AND INSTRUMENT COMBINATION TEMPLATE

A. 510(k) Number:

k173345

B. Purpose for Submission:

Addition of ketone detection functionality to a previously cleared device, the Smart Dongle Blood Glucose Monitoring System (k162382).

C. Measurand:

β-Ketone, as beta-hydroxybutyrate, in capillary whole blood from fingertip

D. Type of Test:

Quantitative Amperometric β-Ketone (beta-hydroxybutyrate)

E. Applicant:

TaiDoc Technology Corporation

F. Proprietary and Established Names:

TD-4140 Smart Dongle Blood Glucose plus β-ketone Monitoring System

G. Regulatory Information:

1. Regulation section:

   21 CFR 862.1435, Ketones (nonquantitative) test system

2. Classification:

   Class I, meets limitation of exemption 21 CFR 862.9 (c)(5)

3. Product code:

   JIN – Nitroprusside, ketones (urinary, non-quant.)

4. Panel:

   (75) Chemistry

H. Intended Use:

1. Intended use(s):

   See indications for use below.

2. Indication(s) for use:
   The TD-4140 Smart Dongle Blood Glucose plus β-ketone Monitoring System consists of the Smart Dongle meter, Smart Dongle blood glucose test strips, Smart Dongle β -ketone test strips, β-ketone control solution and the Procheck mobile application as the display component of the system. This system is intended to be used for the quantitative measurement of glucose (sugar) and β-ketone in fresh capillary whole blood from the finger.

   This system is intended for self-testing outside the body (in vitro diagnostic use) by people with diabetes at home as an aid to monitor the effectiveness of diabetes control. It is intended to be used by a single person and should not be shared. This system should not be used for the diagnosis of or screening for diabetes, nor for use on neonates.

3. Special conditions for use statement(s):

   - For *in vitro* diagnostic use (for use outside of the body only).
   - For single use only.
   - Use only fresh capillary whole blood from the fingertips.
   - The meter and lancing device are for single patient use. Do not share them with anyone including other family members! Do not use on multiple patients!
   - All parts of the kit are considered biohazardous and can potentially transmit infectious diseases, even after you have performed cleaning and disinfection.
   - This system should not be used on critically ill patients, severely hypotensive individuals, or patients in shock.
   - Severe dehydration and excessive water loss may cause inaccurate readings.
   - This system is not for use on patients in hyperglycemic-hyperosmolar state, with or without ketosis.
   - This system should not be used on patients with impaired peripheral circulation, severe dehydration as a result of diabetic ketoacidosis, or severe hyperglycemia hyperosmolar non-ketotic coma.
   - This system should not be used for the diagnosis of or screening for diabetes.
   - Neonatal Use: These test strips are not for use with neonates.

4. Special instrument requirements:
   - TD-4140 Smart Dongle Meter

- ProCheck Mobile App
- Apple iPhone 4, 4s, 5, 5s, 6, 6+, 6s+,
- iPod touch 5.
- Apple iOS version 7, 8, 9 and 10

I. Device Description:

The TD-4140 Smart Dongle Blood Glucose plus β-ketone Monitoring System is comprised of the Smart Dongle meter, Smart Dongle blood glucose test strips, Smart Dongle β-ketone test strips, β-ketone control solutions and the ProCheck Mobile app. The measurement result is transmitted to a compatible mobile device via headphone jack. The ProCheck App within this system is used for analysis and storage of the data. Test results will show on the screen after 5 seconds' reaction time. The proposed device does not need a battery, and is powered by the mobile device.

J. Substantial Equivalence Information:

1. Predicate device name(s):

   FORA ADVANCED GD40 Blood Glucose and β-Ketone Monitoring System

2. Predicate 510(k) number(s):

   k161738

3. Comparison with predicate:

Similarities		
Item	Candidate: TD-4140 Smart Dongle Blood Glucose plus β-ketone Monitoring System	Predicate: FORA ADVANCED GD40 Blood Glucose and β-Ketone Monitoring System, k161738
Intended use	Quantitative measurement of glucose and β-ketone in fresh capillary whole blood from the finger by people with diabetes at home as an aid to monitor the effectiveness of diabetes control.	Same
Sample Type	Capillary whole blood	Same
Assay Method	β-hydroxybutyrate dehydrogenase	Same
Ketones Measuring range	0.1 - 8.0 mmol/L	Same
Sample size	1.0 µL	Same
Hematocrit range	20-70%	Same

Differences		
Item	Candidate: TD-4140 Smart Dongle Blood Glucose plus β-ketone Monitoring System	Predicate: FORA ADVANCED GD40 Blood Glucose and β-Ketone Monitoring System, k161738
Operating conditions	10 °C – 40 °C, 10% – 85% R.H.	10 °C – 40 °C, 10% – 90% R.H.
Data storage	Results stored by mobile platform	Data storage in the device
Data transmission	Headphone jack	RS-232 4 Poles
Display	Displayed on mobile platform: iPhone 4, iPhone 4s, iPhone 5, iPhone 5s, iPhone 6, iPhone 6 plus, iPhone 6s, iPhone 6s plus and iPod touch 5th generation	LCD

K. Standard/Guidance Document Referenced (if applicable):

- Clinical and Laboratory Standards Institute (CLSI) EP05-A2 Evaluation of precision performance of quantitative measurement methods
- CLSI EP06 Evaluation of the linearity of quantitative analytical methods
- CLSI EP07-A2 Interference testing in clinical chemistry
- IEC 60601-1-2 Medical electrical equipment - part 1-2: general requirements for basic safety and essential performance - collateral standard: electromagnetic compatibility - requirements and test
- IEC-62304 Medical device software - Software life cycle processes

L. Test Principle:

β-hydroxybutyrate (β-ketone) measurement is based on electrochemical biosensor technology using the enzyme β-hydroxybutyrate dehydrogenase. The electrical current resulting from this enzymatic reaction is measured and correlated to β-ketone concentration by the meter. The magnitude of electrical current resulting from this enzymatic reaction is proportional to the amount of β-hydroxybutyrate present in the sample. The result is displayed for the user on the mobile device using the ProCheck Mobile application.

M. Performance Characteristics:

1. <u>Analytical performance:</u>

   Performance characteristics for the glucose measurement function with this device

(formerly named Smart Dongle Blood Gucose Monitoring System) was previously reviewed and cleared in k162382.

Performance characteristics for the β-ketone measurement function are described below using the iPod touch 5 with iOS 8 as a representative mobile device.

a. Precision/Reproducibility:

Repeatability:
Precision was evaluated using venous blood samples adjusted to three different β-ketone concentrations (0.5, 2.9, and 5.0 mmol/L) and tested on ten TD-4140 Smart Dongle Blood Glucose plus β-Ketone Monitoring meters and three lots of test strips. Ten replicates were tested per meter per glucose concentration for a total of 300 results per ketone level. The results from all strip lots are summarized below:

Ketone Level (mmol/L)	Lot	N	Mean (mmol/L)	SD (mmol/L)	CV (%)
0.5	1	100	0.530	0.048	9.11
	2	100	0.510	0.057	11.13
	3	100	0.520	0.063	10.59
2.9	1	100	2.880	0.092	3.19
	2	100	2.910	0.088	3.01
	3	100	2.870	0.095	3.31
5.0	1	100	5.030	0.157	3.12
	2	100	5.010	0.160	3.18
	3	100	5.050	0.158	3.13

Intermediate Precision:
Intermediate precision was evaluated using three lots of test strips and ten TD-4140 Smart Dongle Blood Glucose plusβ-Ketone Monitoring meters. Two levels of ketone control solutions were used (0.3-0.9 mmol/L and 2.0-4.0 mmol/L). For each level of control, ten replicates were taken each day for ten days, so that 300 individual measurements were generated per control level. The results from all strip lots are summarized below:

Ketone Level (mmol/L)	Lot	N	Mean (mmol/L)	SD (mmol/L)	CV (%)
0.3-0.9	1	100	0.580	0.042	7.27
	2	100	0.590	0.032	5.36
	3	100	0.610	0.032	5.18
2.0-4.0	1	100	2.620	0.063	2.41
	2	100	2.550	0.071	2.77
	3	100	2.580	0.063	2.45

b. *Linearity/assay reportable range:*
Linearity for ketones was evaluated using three lots of test strips and five TD-4140 Smart Dongle Blood Glucose plus β-Ketone Monitoring meters. Six (6) venous samples were supplemented with β-ketone concentrations to the following β-ketone concentrations: <0.2, 0.5, 1.0, 2.0, 4.0, and 8.0 mmol/L. Linear regression analysis for each lot compared to results obtained using β-Hydroxybutyrate LiquiColor using Helios Zeta UV-Visible spectrophotometer resulted in the following:

Lot no.	Linear regression	Range
1	y = 0.9971x +0.0027; R2 = 0.9986	0.06-8.67 mmol/L
2	y = 1.0027x – 0.332; R2 = 0.998	0.06-8.67 mmol/L
3	y = 1.0034x + 0.104; R2 = 0.998	0.06-8.67 mmol/L

The results of the study support the sponsor's claimed range of β-ketone of 0.1 - 8.0 mmol/L. The meter displays "Lo" when sample are below (<0.1 mmol/L) and "Hi" when samples are greater than (0.8mmol/L). Testing was performed demonstrating that these features function as intended.

c. *Traceability, Stability, Expected values (controls, calibrators, or methods):*

Traceability:
The TD-4140 Smart Dongle Blood Glucose plus β-ketone Monitoring System and are traceable to an in-house standard prepared from commercially available control materials. β-Hydroxybutyrate LiquiColor assay on the Helios Zeta UV-Visible spectro-photometer was used as the comparator method in the lay-user accuracy study.

Ketone test strip stability
Stability protocols and acceptance criteria were reviewed and found to be acceptable to support a shelf life of 20 months and an open-vial use life of three months when stored at a temperature ranging from 35.6 °F-86°F (2°C to 30°C) and between 10%-85% relative humidity.

d. *Detection limit:*
Ketone measuring range is 0.1-8.0 mmol/L, these ranges are validated via the linearity study. See section M.1.b.

e. *Analytical specificity:*
Interference testing was performed to evaluate exogenous and endogenous substances using venous blood spiked to two β-Ketone levels of 1.0 and 3.0 mmol/L. The samples were divided into 2 aliquots: control (with no added interferent) and test samples (with added potential interferent). Each sample was measured by the β-Hydroxybutyrate LiquiColor assay and four TD-4140 Smart Dongle Blood Glucose plus β-Ketone Monitoring system. The sponsor defines no significant interference as bias < ± 10% for the test compared to control samples. The following table lists the concentrations of each substance at which no significant interference was detected:

Substance	Highest concentration tested at which no significant interference is observed (mg/dL)
Acetoacetate	20.0
Acetone	70
Acetylsalicylic acid	50
Acyclovir	3.1
Allopurinol	5
Amitriptylline	0.27
Amoxicillin	12.5
Ampicillin	5
Ascorbic Acid	4
Aspirin	60
Atenolol	10
Bicarbonate	336
Caffeine	10
Calcium	5 mM
Captopril	500
Chloride	140 mM
Cholesterol	500
Cholic acid	6
Clonidine	2
Creatinine	5
Digoxin	0.16
Diphenhydramine	1
Dopamine	0.09
Enalapril	0.15
Ephedrine HCl	60
Erythromycin	20
Estrone	0.1
Famotidine	0.13
Fluoxetine	0.8
Fructose	1000
Furosemide	2
Galactose	13.87 mmol/L
Gamma-Globulin (Total Protein)	12000
Gentisic acid	1.8
Glyburide	1.07
Ibuprofen	55
Isomalt	1000
Lactose	1000
Lactitol	1000
Levo-dopa	0.6

Substance	Highest concentration tested at which no significant interference is observed (mg/dL)
Lidocaine	6
Magnesium	5mM
Maltitol	1000
Maltose	1000
Mannitol	1000
Metaproterol	1.81
Metformin HCl	50
Methyl-Dopa	59.18
Metoprolol	0.3
N-acetlycysteine	0.038
Naproxen	100
Nifedipine	0.17
Nortriptyline	0.15
Paracetamol (Acetaminophen)	25
Penicillin	12
Phenytoin	10
Piroxicam	5
Potassium	10mM
Sodium	200mM
Sorbitol	1000
Sulfamethoxazole	120
Sulfate	5mM
Terfenadine	0.45
Tetracycline	4
Theophylline	25
Tolazamide	321
Tolbutamide	64
Triglycerides	1500
Unconjugated bilirubin	20
Urea	600
Uric acid	24
Vancomycin	25
Verapamil	0.45
Vitamin E	20
Warfarin	2
Xylitol	1000
Xylose	1000

In the labeling, the sponsor includes the following limitation:
"If you are taking vitamin C (ascorbic acid) more than the recommended levels >3 mg/dL, then your ketone level results may be inaccurate with this system. If you are unsure, then ask your doctor."

f. Assay cut-off:

Not applicable.

2. Comparison studies:
   a. Method comparison with predicate device:

   Not applicable.

   b. Matrix comparison:

   Not applicable.

3. Clinical studies:
   a. Clinical Sensitivity:

   Not applicable.

   b. Clinical specificity:

   Not applicable.

   c. Other clinical supportive data (when a. and b. are not applicable):

   Lay user Study:

   To assess the ketone performance of the TD-4140 Smart Dongle Blood Glucose plus β-ketone Monitoring System in the hands of the intended users the sponsor performed a study with 120 lay user participants. Participants obtained and tested their own fingerstick samples with the TD-4140 Smart Dongle Blood Glucose plus β-ketone Monitoring System. β-Ketone results from the meter obtained by the lay user were compared to the β-Hydroxybutyrate LiquiColor assay using Helios Zeta UV-Visible spectrophotometer. The samples ranged from 0.1 to 6.7 mmol/L. Results of the meter measurements relative to the comparator method are summarized below:

   Ketone concentration <2 mmol/L

Within ± 0.3 mmol/L	Within ± 0.5 mmol/L
80/89 (89.9%)	89/89 (100%)

Ketone concentration ≥2 mmol/L

Within ±5%	Within ±10%	Within ±15%	Within ±20%	Within ±25%
15/31 (48.4%)	25/31 (80.6%)	30/31 (96.8%)	30/31 (96.8%)	31/31 (100%)

Results of the linear regression analysis:

$y=1.0186x - 0.0427$, $R^2= 0.9786$

4. Clinical cut-off**:**
   Not applicable.

5. Expected values/Reference range:

   Based on published literature, the sponsor included < 0.6 mmol/L as the expected value for ketones and cites the following reference:
   Tietz NW. Clinical Guide to Laboratory Tests. 3rd ed. Philadelphia, PA: WB Saunders Company;4th Edition.

N. Instrumet Name:

TD-4140 Smart Dongle Blood Glucose plus β-ketone Monitoring System

O. System Descriptions:

1. Modes of Operation:

   Does the applicant's device contain the ability to transmit data to a computer, webserver, or mobile device?

   Yes ___x_____ or No _____

   Does the applicant's device transmit data to a computer, webserver, or mobile device using wireless transmission?

   Yes ___x_____ or No _____

2. Software:

   FDA has reviewed applicant's Hazard Analysis and software development processes for this line of product types:

   Yes ___x_____ or No _____

3. Specimen Identification:

   There is no sample identification function with this device. Samples are applied directly to the test strip as they are collected.

4. Specimen Sampling and Handling:

   The device is intended to be used with capillary whole blood from the finger. The whole blood sample is applied directly to the test strip by capillary action therefore there are no special handling or storage issues.

5. Calibration:

   Coding by the user is necessary for β-Ketone. A code strip is provided and the user is instructed to calibrate every time a new vial of ketone test strips is begun by comparing the code number on the ProCheck mobile app.

6. Quality Control:

   The sponsor provides 2 levels of β-Ketone Control Solutions, all sold separately. The outer kit box labels state that controls are necessary but not included and must be purchased separately.

P. Other Supportive Instrument Performance Characteristics Data Not Covered In The "Performance Characteristics" Section above:

1. **Sample volume study**:
   A sample volume study was performed using venous whole blood samples. Three samples were spiked to β-Ketone levels of 0.5, 2.0, and 4.0 mmol/L, as measured by the β-Hydroxybutyrate LiquiColor method, to evaluate the effect of different sample volumes (0.8, 0.9, 1.0, 1.1, 1.2, and 1.3 mmol/L on the β-Ketone performance of the device. Three lots of test strips and 5 meters were used. Results from these studies support the claimed minimum sample volume 1.0 µL for β-Ketone. The meter displays an error message (Err.45.), 2.9, 4.8 and 7.3 mmol/L, as measured by the β-Hydroxybutyrate LiquiColor method. The samples were tested with 6 meters and the results were compared to the β-Hydroxybutyrate LiquiColor method and the normal 40% hematocrit. The % biases relative to the β-Hydroxybutyrate LiquiColor method were acceptable within the claimed hematocrit range and support the claimed hematocrit range of 20 to 70%.

2. **Test System Operating Conditions:**
   Operating temperature and humidity conditions were evaluated using a single lot of ketone test strips and four meters with venous whole blood samples three β-Ketone levels (0.5, 2.0, and 4.0 mmol/L) using the β-Hydroxybutyrate LiquiColor® as reference method. The following temperature and humidity conditions were tested: 50°F (10°C)/10% RH, 50°F (10°C)/85% RH, 104°F (40°C)/10%RH, and 104°F (40°C)/85%

RH. The results support the sponsor's claimed operating temperature from 50°F to 104°F (10°C - 40°C) and relative humidity range from 10-85%.

3. **EMC Testing:**
   The sponsor provided documentation certifying that acceptable electromagnetic testing (EMC) had been performed and the device system was found compliant.

4. **Infection Control Studies:**
   The TD-4140 Smart Dongle Blood Glucose plus β-ketone Monitoring System meter is intended for single-patient use. Disinfection efficacy studies were performed on the materials comprising the meters by an outside commercial laboratory (in the predicate k162382) demonstrating complete inactivation of hepatitis B virus (HBV) with Micro-Kill Wipes (EPA Reg. No. 59894-10-37549). Robustness studies were performed by the sponsor demonstrating that there was no change in performance or in external materials of the meters after 10,950 cleaning and disinfection cycles with Micro-Kill Wipes. The robustness studies were designed to simulate 5 years of single-patient use. Labeling was reviewed for adequate instructions for the validated cleaning and disinfection procedures.

Q. Proposed Labeling:

The labeling is sufficient and it satisfies the requirements of 21 CFR Parts 801 and 809, as applicable.

R. Conclusion:

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