510(k) SUBSTANTIAL EQUIVALENCE DETERMINATION
DECISION SUMMARY

I Background Information:

A 510(k) Number

K200828

B Applicant

Athelas Inc.

C Proprietary and Established Names

Athelas Home

D Regulatory Information

Product Code(s)	Classification	Regulation Section	Panel
GKZ	Class II	21 CFR 864.5220 - Automated Differential Cell Counter	HE - Hematology

II Submission/Device Overview:

A Purpose for Submission:

New device

B Measurand:

White blood cell count (WBC) and percent neutrophil count (NEUT%)

C Type of Test:

Quantitative

III Intended Use/Indications for Use:

A Intended Use(s):

See Indications for Use below.

B Indication(s) for Use:

The Athelas Home is indicated for the quantitative determination of white blood cells (WBC) and Neutrophil percentages (NEUT%) in capillary whole blood. The Athelas Home system is for In Vitro Diagnostic use and for prescription use only. The Athelas Home is only to be used with Athelas Home Test Strips. The Athelas Home is indicated for use by patients and caregivers within home settings with results viewable by health care professionals. The Athelas Home is intended for patients at risk of neutropenia. For patients with psychiatric conditions, clinical judgement should be exercised when deciding the end-user, based on the instructions for use (IFU) of Athelas Home, the treating physician should determine which patients are competent to perform the test by themselves. The Athelas Home is indicated for adult populations only (aged 21 and older).

Results obtained with the Athelas Home should not be the sole basis for patient diagnosis, treatment or management of leukopenia and neutropenia. All results should be evaluated by a healthcare provider.

The Athelas Home is intended to be used by a single person and should not be shared.

Prescription Use Only.

C Special Conditions for Use Statement(s):
Rx - For Prescription Use Only

D Special Instrument Requirements:

Athelas Home

IV Device/System Characteristics:

A Device Description:

The Athelas Home is an automated cell counter system which consists of the Athelas Home analyzer and the Athelas Home Test Strips. The Athelas Home is identical to the Athelas One (K181288) in its technology, all software, the analytes measured, all components, and usage process. The Athelas Home has additional software and quality control safeguards to enable at-home usage of the device. Additionally, results generated from the Athelas Home are not shown to end-patients, rather are transmitted via the software directly to their healthcare provider. The Athelas Home also has Remote Lockout capabilities, such that a healthcare provider or manufacturer can remotely lock-out a device for safety in usage.

The Athelas Home Tests Strips collects a capillary whole blood sample to generate a layer of cells for counting and image analysis. The Athelas Home Test Strips are comprised of an upper optical panel, lower optical panel and a stain coated region containing methylene blue and cresyl violet stains. The test strip channel is optically clear for the camera module to take pictures of the cells in the blood sample.

A smartphone/tablet with the Athelas controlling mobile application is required to initiate a test with the Athelas Home System. The smartphone/tablet models compatible to initiate testing are those devices supporting iOS 9 and up, or Android 8 and up.

B Principle of Operation:

The Athelas Home uses image processing and microfluidics in order to measure WBC and NEUT% values from whole blood in home settings. The Athelas Home system consists of the Athelas Home analyzer and Athelas Home test strips. The Athelas Home test strips serve as both a sample container and a reaction chamber. A capillary whole blood sample is directly transferred via fingerstick to the Athelas Home test strip which automatically spreads the sample into a monolayer. The pre-coated stain within the strip chamber interacts with the monolayer of blood and stains the WBCs. The Athelas Home test strip is inserted into the Athelas Home analyzer which utilizes a proximity sensor to lock in place. A servo stabilizes and auto-focuses the blood sample, and then a stage actuator scans the strip across various fields while the optical module takes multiple images of the cells across the monolayer. The images of the blood sample are transmitted to the server where they are analyzed using a locked down image processing algorithm. The algorithm recognizes the nucleation and WBCs to generate a WBC count and NEUT% result based on the concentrations and types of cells present.

Instrument Description Information:

1. Instrument Name:

   Athelas Home

2. Specimen Identification:

   Capillary whole blood

3. Specimen Sampling and Handling:

   A capillary whole blood sample is directly transferred via fingerstick to the Athelas Home test strip which is inserted into the Athelas Home analyzer.

4. Calibration:

   Factory calibrated and automatic calibration at the beginning of each test. No manual calibration by the end user.

5. Quality Control:

   Auto-Check 3-Level Gridded Strip
   OR ATH-CHECK (3 level control)

V Substantial Equivalence Information:

A Predicate Device Name(s):
Athelas One

B Predicate 510(k) Number(s):
K181288

C Comparison with Predicate(s):

Device & Predicate Device(s):	K200828	K181288
Device Trade Name	Athelas Home	Athelas One
General Device Characteristic Similarities		
Intended Use/Indications For Use	The Athelas Home is indicated for the quantitative determination of white blood cells (WBC) and Neutrophil percentages (NEUT%) in capillary whole blood. The Athelas Home system is for In Vitro Diagnostic use and for prescription use only. The Athelas Home is only to be used with Athelas Home Test Strips. The Athelas Home is indicated for use by patients and caregivers within home settings with results viewable by health care professionals. The Athelas Home is intended for patients at risk of neutropenia. For patients with psychiatric conditions, clinical judgement should be exercised when deciding the end-user, based on the instructions for use (IFU) of Athelas Home, the treating physician should determine which patients are competent to perform the test by themselves. The Athelas Home is indicated for adult	Athelas One is indicated for use for quantitative determination of white blood cells (WBC) and Neutrophil percentages (NEUT%) in capillary or K2EDTA venous whole blood. The Athelas One system is for In Vitro Diagnostic use only. The Athelas One is only to be used with Athelas One Test Strips. The Athelas One is indicated for use in clinical laboratories and for point of care settings. The Athelas One is only indicated for use in adult populations (aged 21 and older).

Device & Predicate Device(s):	K200828	K181288
Device Trade Name	Athelas Home	Athelas One
General Device Characteristic Similarities		
	populations only (aged 21 and older). Results obtained with the Athelas Home should not be the sole basis for patient diagnosis, treatment or management of leukopenia and neutropenia. All results should be evaluated by a healthcare provider. The Athelas Home is intended to be used by a single person and should not be shared. Prescription Use Only.	
Modes of Operation	Single mode of operation for capillary samples	Single mode of operation for both venous and capillary samples
Software/Hardware	Internet connected device for processing results on cloud server	Same
Sample Volume	3.5 µL	Same
Measurement Range	WBC: 1–25 $x10^3/\mu L$ NEUT%: 0–100%	Same
Calibration	Factory calibrated and automatic calibration at the beginning of each test. No manual calibration by the end user	Same

Device & Predicate Device(s):	K200828	K181288
Device Trade Name	Athelas Home	Athelas One
General Device Characteristic Similarities		
Test Principle	A microfluidic test strip channel creates a stained monolayer of white blood cells. Multiple images are taken of the monolayer and the cells are counted and classified by computer vision-based image analysis	Same
Parameters	WBC, NEUT%	Same
Target Population	Adults (aged 21 and older)	Same
Reagents	Cresyl Violet, Methylene Blue Stain (pre-loaded/coated dry and contained in test strip)	Same
Controls/ Calibrators	Auto-Check 3-Level Gridded Strip OR ATH-CHECK (3 level control)	Same
General Device Characteristic Differences		
Intended Use Settings	Home	Point of Care, Clinical Laboratory
Specimen Type	Capillary whole blood	Capillary whole blood and K_2EDTA venous whole blood
Result Viewing	Results are remotely and securely transmitted to the prescribing physician or healthcare provider	Results are shown on the mobile/tablet application used for system operation
Remote Lockout Capability	Yes	No

VI Standards/Guidance Documents Referenced:

CLSI H26-A2: *Validation, Verification and Quality Assurance of Automated Hematology Analyzers; Approved Guideline* – Second Edition

CLSI EP07: *Interference Testing in Clinical Chemistry*, Third Edition

CLSI EP06-A: *Evaluation of the Linearity of Quantitative Measurement Procedures; Approved Guideline*

CLSI EP17-A2: *Evaluation of Detection Capability for Clinical Laboratory Measurement Procedures; Approved Guideline* – Second Edition

CLSI EP35: *Assessment of Equivalency or Suitability of Specimen Types for Medical Laboratory Measurement Procedures;* First Edition

CLSI EP09c-A3: *Measurement Procedure Comparison and Bias Estimation Using Patient Samples*. Third Edition

CLSI EP05-A3: *Evaluation of Precision of Quantitative Measurement Procedures; Approved Guideline* – Third Edition

CLSI EP25-A: *Evaluation of Stability of In Vitro Diagnostic Reagents; Approved Guideline*

CLSI EP28-A3c: *Defining, Establishing, and Verifying Reference Intervals in Clinical Laboratory; Approved Guideline* – Third Edition

VII Performance Characteristics (if/when applicable):

A Analytical Performance:

1. Precision:

Two separate precision studies were performed to evaluate the performance of the Athelas Home by home users. The precision studies were conducted in the home environment with an Athelas Home device system.

a. A group of 24 patients were instructed to conduct tests on the Athelas Home following the instructions for use. Each patient collected two capillary whole blood samples from finger pricks (from different fingers) within five minutes of each other, filling two unique test strips for measurements. The precision profile approach was used to estimate repeatability as shown in the table below.

WBC Mean (x 10^3/µL)	Interval	SD	%CV
2.53	1.0–4.3	0.071	2.8%
6.12	4.7–7.6	0.379	6.2%
11.78	9.8–13.9	0.89	7.6%

NEUT% Mean	Interval	SD	%CV
36%	27–48%	2.08	5.8%
56%	51–59%	2.03	3.7%
66%	55–80%	3.16	4.8%

b. A separate group of 10 patients were provided with Athelas Home Quality Control materials (low, moderate, and high levels). They used the dropper on the Quality Control material vial to conduct triplicate measurements for the assigned sample by the given patient. The precision profile approach was used to estimate repeatability for the home users using the Quality Control materials. The result was presented in the table below.

Sample	N	WBC Mean (x 10^3/µL)	SD	%CV
Low QC	15	2.79	0.288	10.3%
Medium QC	9	7.76	0.271	3.5%
High QC	6	22.78	1.087	4.8%

2. Linearity:

Refer to K181288

3. Analytical Specificity/Interference:

Refer to K181288

4. Assay Reportable Range:

The reportable range for white blood cells (WBC) is 1.0–25.0 x 10^3/µL.

5. Traceability, Stability, Expected Values (Controls, Calibrators, or Methods):

Reference range from K181288:

Parameter	Male (N = 60)		Female (N = 60)	
	Lower Limit	Upper Limit	Lower Limit	Upper Limit
WBC (x10^3/µL)	3.91	10.90	4.49	12.68
NEUT%	41.0	70.7	42.9	74.3

6. Detection Limit:

Refer to K181288

7. Assay Cut-Off:

Not applicable

8. Accuracy (Instrument):

Not applicable

9. Carry-Over:

Not applicable

B Comparison Studies:

1. Method Comparison with Predicate Device (At-Home Usability Study):

The study was performed to evaluate the performance of the Athelas Home analyzer in the home setting when compared to the predicate device Athelas One. A total of 61 patients (including patients with neutropenia, patients with autoimmune diseases, patients on immunosuppressive oncology therapy and patients on clozapine) were enrolled in the study, 1–4 visits per patient. Patients (untrained operators) were instructed to conduct tests on the Athelas Home following the labeling process. Fifteen (15) separate lots of test strips were used across all patients in the study. Tests were conducted in a single measurement by home users on the Athelas Home. The trained operators performed triplicate measurements on the predicate device. The average of the triplicates on the predicate performed by trained operator was used for comparison against the single measurement by self-testers and caregivers on the Athelas Home device in the home settings. Passing-Bablok regression was used to evaluate the performance of the Athelas Home. The tables presented below demonstrate the correlation and estimated bias.

Parameter	Interval	N	(r)	Slope (95% CI)	Intercept (95% CI)
WBC	1.3–14.4	117	0.97	1.00 (0.97, 1.05)	0.00 (-0.33, 0.16)
NEUT %	21-78	117	0.95	1.00 (0.93, 1.05)	0.00 (-2.25, 5.00)

Bias at Medical Decision Levels of WBC

WBC Level ($x10^3/\mu L$)	Bias (95% CI)	%Bias (95% CI)
3.9	0.00 (-0.18, 0.10)	0.00% (-4.50%, 2.56%)
10.4	0.00 (-0.19, 0.28)	0.00% (-1.85%, 2.65%)

Bias at Medical Decision Levels of NEUT%

NEUT%	Bias (95% CI)	%Bias (95% CI)
46.4	1.00 (-0.16, 2.00)	2.16% (-0.34%, 4.31%)
76.9	1.00 (-0.66, 2.00)	1.30% (-0.86%, 2.60%)

2. Matrix Comparison:

Not applicable

C Clinical Studies:

1. Clinical Sensitivity:

Not applicable

2. Clinical Specificity:

Not applicable

3. Other Clinical Supportive Data (When 1. and 2. Are Not Applicable):

Not applicable

D Clinical Cut-Off:

Not applicable

E Expected Values/Reference Range:

Refer to K181288

F Other Supportive Instrument Performance Characteristics Data:

1. At-Home Usability Analysis

During the first At-Home visits, study investigators were asked to conduct usability surveys to evaluate home users in setting up the device system for testing and their understanding of how to run the test. The results of this study are described in the table below.

Survey Question	Yes	No
Was the user able to use the lancet correctly? Mark yes if the user was able to open the lancet, puncture the correct site on their finger, and dispose of the lancet correctly.	100% (32/32)	0% (0/32)
Did the user fill up the test-strip fully? Mark yes if the user placed enough blood such that the blood reached the end of the channel on the test-strip.	94% (30/32)	6% (2/30)
Did the user face any errors when running the test (not error codes)?	97% (31/32)	3% (1/32)
Did the user correctly know how to run the test using the application?	100% (32/32)	0% (0/32)
Was this test performed by a caregiver or the patient? ('Yes' if conducted by patient, 'No' if conducted by caregiver)	31% (10/32)	69% (22/32)

2. At-Home Error Analysis

During At-Home testing, flex studies were conducted to verify the usability and ease of use of the Athelas Home when used by patients in the intended use settings. Over 94% of tests were run successfully without errors. Errors were resolved after running a single additional test strip. The results were presented in the table below:

Error Type	Occurrence #	Percent of Tests
No Error	76	94
Test-Strip/Optical Error	3	3.7
Incorrect Insertion Direction	2	2.5
HH! (shows as success to the patient)	1	1.2
LL! (shows as success to the patient)	1	1.2

3. Flex Studies

Delay in Testing After Sample Collection

A study was conducted to evaluate whether there was measurand drift in the analyte results if there was a delay between sampling and running the test strip on device. The study was to test for the case where a user fills the strip and waits for up to 30 minutes before inserting it into the device for analysis. Five different timepoints (5 minutes, 15 minutes, 25 minutes, 30 minutes and 35 minutes) were evaluated across two lots of test strips with two Athelas Home devices. Nine whole blood samples covering the measuring range were used. The linear regression analysis showed no significant measurand drift for tested samples. Results validated the claimed stability up to 30 minutes.

Sample Strip Fill-Volume Testing

To determine whether the Athelas Home correctly handles variable amounts of blood inserted into the test-strip, a study was conducted with variable amounts of blood inserted into the test-strip using three K2EDTA whole blood samples with known WBC and NEUT% values. Each volume sample (0 µL, 1.4 µL, 3.4 µL, and 5.4 µL) was tested in two replicates by using one lot of test strips. Results were found acceptable and met the defined acceptance criteria.

Tilt Testing

A study was conducted to determine whether the Athelas Home is robust against being placed on tilted surfaces in different orientations. Three K2EDTA whole blood samples were tested in two replicates with one lot of test strips on one device. One level of tilt angle was tested (30 degrees) with the analyzer tested in four orientations (front to back, back to front, left to right and right to left). Samples representing a low, normal, and abnormal (high) level of WBC and Neut% were analyzed in triplicates in each test position. Results demonstrate that the Athelas Home is not affected by tilted placement of the device.

Drop Testing

A study was conducted to determine whether the Athelas Home continues to return accurate results after being dropped from multiple orientations and heights. 12 Athelas Home analyzers were tested in accordance with ASTM 1469 - D03. The test method included manual handling, vehicle stacking, loose load vibrations, vehicle vibrations. The Athelas Home were assessed in the following ways: Verify no visible physical damage or degradation; Verify the following functional characteristics (LED function, device stage flatness, ABS surface damage, motor function, liner actuator function and camera function); Verify a single run of the Auto-Check 3-Level Gridded Strip returns results within the specification range. Results demonstrate that all devices continued to pass functional tests after being subjected to the full testing schedules.

Temperature Testing

A study was conducted to verify the performance of the Athelas Home device and test strips after extreme and varying temperature. The study was divided into two parts, one for the analyzer, and another for the test strips. For the device, three Athelas Home devices were placed in the given investigated temperature (-20ºC (extreme low), 20ºC (room temp), 40ºC (extreme high)) for 12 hours and then allowed to return to room temperature for 4 hours. All test strips came from a single lot stored only at room temperature. Auto-Check 3-Level Gridded Strip were tested in three replicates on each device. For the test strips, three lots of Athelas Home test strips were placed in the given temperature ((-20ºC (extreme low), 20ºC (room temp), 40ºC (extreme high)) for 12 hours. The test strips were allowed to return at room temperature for 4 hours. Auto-Check 3-Level Gridded Strip were tested in three replicates on one device only stored at room temperature for each test strip lot. Results demonstrate that both the Athelas Home device and Athelas Home test-strip meet performance specifications after exposure to different temperatures.

Humidity Testing

A study was conducted to verify the performance of the Athelas Home under extreme humidity conditions. The study evaluated the performance of the Athelas Home device after exposure to RH levels (from 30% to 90% RH) outside of the recommended 60% RH. Three Athelas Home analyzers were exposed to three separate simulated conditions for 72 hours. For each simulated condition, tests were performed on the Athelas Home using Auto-Check 3-Level Gridded Strip (Low, Normal, and High) in three replicates. Results demonstrate that the Athelas Home is functional even after exposure to relative humidity levels outside of the specified operational range. Exposure to relative humidity levels within the range tested (up to 72 hours) shows no impact on performance.

Vibration Testing

A study was conducted to ensure that the Athelas Home device can continue to function or return appropriate error codes after exposure to extensive vibration in handling by a patient or shipping. The analyzer was subjected to three levels of vibration: 4.8 millimeters/second (mm/s), 10 mm/s, and 15 mm/s. Samples with different levels (low, medium and high) were tested in triplicates at each vibration level. Results were compared to the same sample levels tested without vibration. All results were within the acceptance criteria and no erroneous results were produced. All low and abnormal (high) samples flagged and/or suppressed as expected.

Ambient Room Light

A study was conducted to verify the performance of the Athelas Home device and test strips for exposure in various ambient lighting conditions during operation. Three devices were used in this study with one device in a fully dark room (0-20 lumens), second device in ambient room light (400-600 lumens), and third device in bright sunlight (3000-6000 lumens). Each device was tested with three runs on an Auto-Check 3-Level Gridded Strip. Results demonstrate that the Athelas Home is capable of performing in a range of ambient lighting conditions from complete darkness to extreme external brightness.

4. Flagging Comparison Study

This study was conducted on Athelas One (identical to Athelas Home) compared to the Sysmex XE-5000 to assess the flagging capabilities (distributional and morphological). This study was performed with 312 patient samples from either capillary whole blood or venous whole blood collected in K_2EDTA anticoagulant. Results met the pre-defined acceptance criteria. Summarized data is presented below for both distributional flags as well as morphological flags.

Distributional Flags

The results of the Athelas One WBC distributional flagging (leukocytosis, leukocytopenia) compared to the Sysmex XE-5000 were divided into two categories: 1) No flags, negative judgement and 2) patients with positive distributional abnormalities with flags present, positive judgement.

		Sysmex XE-5000		
		Positive (Abnormal)	**Negative (Normal)**	**Total**
Athelas One	**Positive (Abnormal)**	34	4	38
	Negative (Normal)	5	269	274
	Total	39	273	312

%Positive Agreement (Sensitivity) = 87.2%; 95% CI: 72.57, 95.70
%Negative Agreement (Specificity) = 98.5%; 95% CI: 96.29, 99.60
%Overall Agreement = 97.12%; 95% CI: 94.59, 98.67

Morphological Flags

The results of the Athelas One WBC morphological flagging (nucleated RBCs, platelet clumps, etc.) compared to the Sysmex XE-5000 were divided into two categories: 1) No flags, negative judgement and 2) patients with positive distributional abnormalities with flags present, positive judgement.

		Sysmex XE-5000		
		Positive (Abnormal)	**Negative (Normal)**	**Total**
Athelas One	**Positive (Abnornal)**	90	7	97
	Negative (Normal)	9	206	215
	Total	99	213	312

%Positive Agreement (Sensitivity) = 90.91%; 95% CI: 83.44, 95.76
%Negative Agreement (Specificity) = 96.71%; 95% CI: 93.35, 98.67
%Overall Agreement = 94.87%; 95% CI: 91.81, 97.04

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.