

**DE NOVO CLASSIFICATION REQUEST FOR
PIXEL 3 SYSTEM**

REGULATORY INFORMATION

FDA identifies this generic type of device as:

Image processing device for estimation of external blood loss: An image processing device for estimation of external blood loss is a device to be used as an aid in estimation of patient external blood loss. The device may include software and/or hardware that is used to process images capturing externally lost blood to estimate the hemoglobin mass and/or the blood volume present in the images.

NEW REGULATION NUMBER: 21 CFR 880.2750

CLASSIFICATION: II

PRODUCT CODE: PBZ

BACKGROUND

DEVICE NAME: PIXEL 3 SYSTEM

SUBMISSION NUMBER: K130190

DATE OF DE NOVO: FEBRUARY 4, 2013

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REQUESTER'S RECOMMENDED CLASSIFICATION: II

INDICATIONS FOR USE

The Pixel 3 System is a software application intended to be used as an adjunct in the estimation of blood loss and management of surgical sponges.

The Pixel 3 System is intended to be used with surgical sponges, software, hardware and accessory devices which have been validated for use with the Pixel 3 System to estimate the hemoglobin (Hb) mass contained on used surgical sponges. The Pixel 3 System is also intended to calculate an estimate of blood volume on used surgical sponges from the estimated Hb mass and a user-entered patient serum Hb value. The validated surgical sponges, hardware, software, accessory devices and Hb mass ranges are listed in the Instructions for Use.

The Pixel 3 System is also indicated for use to aid in counting surgical sponges and may be used to record and display case-specific blood components infused over time. The Pixel 3 System is additionally indicated for use to aid in managing surgical sponges, including providing a visual record of sponge images, and to record the user-entered weight of used surgical sponges in order to calculate an estimate of fluid volume on the sponges.

LIMITATIONS

The sale, distribution, and use of the Pixel 3 System are restricted to prescription use in accordance with 21 CFR 801.109.

Limitations on device use are also achieved through the following statements included in the Instructions for Use:

Warning: “The device is MR Unsafe. Do not bring the device into an MR environment. The device must not be used in an MR environment.”

Warning: “The table computer (iPad) is not a sterile device and should remain outside the sterile field.”

Warning: “Information provided by Pixel 3 should not be used as a “trigger” for any clinical action. Patient vital signs such as blood pressure, heart rate, pulse pressure variability, central venous pressure, urine output, respiratory rate, pulse oximeter readings, laboratory-derived Hb, cardiac output, the general clinical presentation of the patient, and your clinical practices should also be used to evaluate the patient before making significant clinical decisions. When the clinical presentation of the patient does not appear consistent with the sHbL [estimated Hb mass lost onto the sponge] or sEBL [estimated cumulative blood volume lost onto the sponges] readings, estimating blood loss by another method (e.g., gravimetric method and/or visual estimation) may be warranted.”

“The Pixel 3 System’s sHbL estimates have only been validated for patient hemoglobin levels from 5 to 17 g/dl and sponges containing up to 6.0 g of hemoglobin.”

“The Pixel 3 System will not provide sHbL and sEBL by sHbL outputs for out-of-range sponges but out-of-range sponges will be counted for the total sponge count. You should estimate blood loss on out-of-range sponges via alternate methods (e.g., gravimetric method and/or visual estimation).”

“sHbL (and the ensuing calculated sEBL) only represent the Hb mass and blood that is estimated to be present on the sponge at the time of scanning. This information is only one aspect of blood loss estimation.”

“The sEBL calculator is simply an aid in the assessment of total blood loss (in ml) based on a user-input laboratory-derived Hb value. The accuracy of the sEBL displayed is dependent on the timeliness of the user-entered laboratory-derived Hb concentration of the patient.”

“The effect of other materials (e.g., bile, stool, urine, colored irrigation fluids or contrast dyes) on the accuracy of the Pixel 3 System’s outputs is unknown.”

“Validated hardware, surgical materials and optional accessories (not provided by Gauss Surgical, Inc.)

- iPad2 Model Number A1395 (EMC 2560) running iOS 6.1 (Contact Gauss prior to updating the iPad operating system), Apple Inc.
- Surgical sponges:
 - *NovaPlus™ Lap Sponges 18x18*
 - *AMD Ritmed 18x18 Laparotomy Sponges*
 - *RFDetect Premium 18x18 Laparotomy Sponges*
 - *Allegiance® Disposable 18x18 Lap Sponges*
- AirTurn BT-105 with 2 ATFS-2 Pedals and Pedal Board; AirTurn, Inc., www.airturn.com”

PLEASE REFER TO THE LABELING FOR A MORE COMPLETE LIST OF WARNINGS AND PRECAUTIONS.

DEVICE DESCRIPTION

The Pixel 3 System is a software program (mobile medical application) used on an Apple iPad® tablet to capture images of used surgical sponges to assist surgical personnel in the management of surgical sponges after surgical use and to aid in the estimation of blood loss. The main functions of the device are summarized below.

The Pixel 3 System provides an estimate of the Hb mass lost onto the sponge (sHbL), which is derived from a software algorithm that analyzes images of sponges sent to the Gauss off-site server along with user-entered information about the type of sponge. An estimate of the cumulative blood volume lost onto the sponges (sEBL) is subsequently calculated by dividing the sHbL for each sponge by a user-entered value for the patient’s laboratory-derived serum Hb level at the time of image capture. Whereas sHbL is estimated independently from the laboratory-derived serum Hb (i.e., directly from each image), sEBL is derived from a calculator whose inputs are adjustable by the user. The Pixel 3 System provides this estimate of blood content on sponges (i.e., sEBL by sHbL method) and estimate of sHbL only for the validated laparotomy sponge types listed in Table 1.

Table 1: Sponge types validated for the sHbL and sEBL by sHbL methods with the Pixel 3 System and corresponding validated ranges of Hb mass.

Sponge Type	Validated Range of Hb Mass
NovaPlus™ 18x18 Laparotomy Sponges	(b)(4) Trade Secret/CCI
AMD Ritmed 18x18 Laparotomy Sponges	
RFDetect Premium 18x18 Laparotomy Sponges	
Allegiance® Disposable 18x18 Laparotomy Sponges	

The Pixel 3 System may also be used to track the weight of soaked surgical sponges recorded by the user. The device may aid in the estimation of blood loss by calculating an estimate of the cumulative sEBL by weight, provided that a dry and wet weight has been entered for each sponge. This estimate (i.e., sEBL by weight method) is based on the total weight of the soaked sponges less their dry weights normalized by the density of whole blood (1.060 g/mL). For the sEBL by weight method, a user may manually enter sponge types other than those validated for the sEBL by sHbL method (see Table 1 above); however, those sponge types can only be used to calculate sEBL by weight.

The Pixel 3 System also allows surgical personnel to categorize sponges by sponge type and provides an automated ongoing count of the total number of sponge images and sponge images by tag. The device allows for the input and display of case-specific values pertaining to fluid management during surgical procedures (e.g., packed red blood cell volume administered over time, fresh frozen plasma volume administered over time, platelet volume administered over time), as detailed in the Instructions for Use. The Pixel 3 System also provides a visual record of images for further evaluation during the surgical case.

To use the device, the user mounts the iPad tablet onto an IV pole; the device contains alignment indicators to help the user align the iPad on the IV pole. The user then places a sponge in view of the iPad camera (the device contains a camera-bounding box to help the user with sponge placement), and scans an image of the sponge by touching the iPad screen or using an optional wireless foot pedal. The device also contains an ambient light indicator, which helps the user determine when a poor (indicator is yellow) or appropriate (indicator is white) level of ambient light is present for image capture.

The full-screen display of sHbL and sEBL by sHbL outputs includes an estimate of the cumulative error of the Pixel 3 System, computed as the 95% Bland-Altman Limits of Agreement (and denoted as “95% limits Bland Altman” on the display). The display of estimated error is updated on a real-time basis, as successive sponges are accumulated and scanned. A Bland-Altman plot in biostatistics is a method of data plotting used to analyze the agreement between two different assays. Bias is defined as the arithmetic mean of the differences between the device’s output value and measurements obtained using a reference standard. The Bland-Altman Limits of Agreement represent two standard deviations (1.96 x SD) of the differences around the bias, and represent the error range within which 95% of all differences between the device’s output and the reference standard’s measures are expected to lie.

Additional details regarding device operation and user instructions can be found in the Instructions for Use. The Instructions for Use are available on the mobile platform during use by selecting the appropriate icon at the bottom of the menu screen.

The Pixel 3 System has been validated for use with the following hardware, software and optional accessories:

- iPad2 Model Number A1395 (EMC 2560) running iOS 6.1, Apple Inc.
- AirTurn BT-105 with 2 ATFS-2 Pedals and Pedal Board; AirTurn, Inc.

SUMMARY OF NONCLINICAL/BENCH STUDIES

The sponsor conducted a series of non-clinical performance testing to demonstrate that the Pixel 3 System would perform as anticipated for its intended use conditions, as described below.

ELECTROMAGNETIC COMPATIBILITY (EMC) AND WIRELESS TECHNOLOGY

EMC testing was performed per the relevant requirements of IEC 60601-1-2:2007 Medical electrical equipment – Part 1-2: General requirements for basic safety and essential performance – Collateral standard: Electromagnetic compatibility – Requirements and tests. EMC testing was conducted to meet the requirements of Class B. Based on successful completion of the testing, the Pixel 3 System is deemed compliant to the relevant requirements of IEC 60601-1-2:2007.

Wireless coexistence testing was performed, which subjected the Pixel 3 System to increasingly noisy wireless environments and evaluation of whether essential wireless functionality performed as needed. Essential functionality was defined as capturing of a sponge image and verifying that the sHbL was received at the iPad within one minute.

The testing environments consisted of the following conditions:

- WCE1 – Nominal Conditions: Free of Interferers
- WCE2 – Single WiFi (neighboring channels), Single Bluetooth Interferers:
- WCE3 – Multiple WiFi, Multiple Bluetooth Interferers
- WCE4 – Multiple WiFi, Multiple Bluetooth, RFID Interferers
- WCE5 – Multiple WiFi, Multiple Bluetooth, RFID Interferers, Maximum Power

The Pixel 3 System was found to maintain essential wireless functionality under all test conditions.

All interferers were placed within 6 inches of the Equipment Under Test. This distance is noted in the Instructions for Use as a wireless separation distance; all other WiFi and Bluetooth devices should be placed further than this distance from the Pixel 3 iPad and foot pedal. The Pixel 3 was not tested in the presence of MRI, CT, diathermy, and electromagnetic security systems such as metal detectors; this is noted in the Instructions for Use.

MAGNETIC RESONANCE (MR) COMPATIBILITY

No testing has been conducted to demonstrate whether the device is MR compatible. The labeling includes a Warning that states “The device is MR Unsafe. Do not bring the device into an MR environment. The device must not be used in an MR environment.”

SOFTWARE

The Agency considers the Pixel 3 System to be of a moderate level of concern (LOC) because inaccurate estimated blood loss may result in serious consequences to health.

All of the elements of software information corresponding to moderate LOC devices as outlined in FDA's *Guidance for the Content of Premarket Submissions for Software Contained in Medical Devices* (issued May 11, 2005) have been provided. The sponsor provided adequate documentation describing the software development program. In addition, the sponsor provided documentation that they performed a hazard analysis from both the patient's and user's standpoint, addressed those hazards, and carried out an appropriate validation process. The verification and validation testing documentation provided an acceptable description of the validation and verification activities, which included system level test protocols, the pass/fail criteria, and the results of these activities. In addition, the sponsor provided a description of the cybersecurity issues involved in the control and use of the device, and the mitigation of the risks arising therefrom.

Overall, the software documentation included in the *de novo* request is in sufficient detail to provide reasonable assurance that the software performs as intended and all software-related risks have been adequately mitigated.

PERFORMANCE TESTING – BENCH

Bench testing demonstrated that the Pixel 3 System performs as expected under anticipated conditions of use. Bench top verification and validation studies were performed to evaluate the accuracy of the device in comparison to known Hb mass poured on sponges.

(b)(4) Trade Secret/CCI

. Blood was then poured onto 50 sponges of each type (see below) and normal saline added at various volumes to vary the sponge saturation. Each sponge was scanned with the Pixel 3 System across three ambient light settings (see below) for a (b)(4) Trade Secret/CCI scans per sponge type.

Multiple conditions/variables were tested to determine potentially significant covariates, including the following:

- Sponge type (four brands)
 - NovaPlus™ Lap Sponges 18x18
 - AMD Ritmed 18x18 Laparotomy Sponges
 - RFDetect Premium 18x18 Laparotomy Sponges
 - Allegiance® Disposable 18x18 Lap Sponges
- Source Hb concentration (g/dl)
 - Range: (b)(4) Trade Secret/CCI
- Fluid volume per sponge (ml)
 - Range: (b)(4) Trade Secret/CCI
- Blood volume per sponge (ml)
 - Range: (b)(4) Trade Secret/CCI
- Hb mass per sponge (g)
 - Range: (b)(4) Trade Secret/CCI
- Blood volume saturation (%)

- Range: Derived from variables listed above
- Hb mass saturation (%)
 - Range: Derived from variables listed above
- Brightness/ambient light conditions
 - (b)(4) Trade Secret/CCI
 - Range: (b)(4) Trade S

The pre-determined acceptance criterion was (b)(4) Trade Secret/CCI per sponge for all sponge types and across all Hb mass ranges. The Hb mass bias differed significantly according to the type of sponge and other covariates listed above for sponges overall ($p \leq 0.001$); however, the Hb mass bias and EBL bias did not differ significantly among different saline volumes for any sponge type. The limits of agreement (bias \pm 2SD) and their corresponding 95% confidence intervals between the Pixel 3 System and the pre-measured Hb mass were approximately \pm 1.2 g per sponge overall and the differences between the two methods followed a normal distribution with a bias (mean difference) of 0.01 g Hb. Overall, the Pixel 3 System had a strong positive linear correlation ($r = 0.92$ [95% CI 0.91 to 0.93]) with the reference method (pre-measured Hb mass deposited in controlled amounts).

PERFORMANCE TESTING – HUMAN FACTORS

Human factors testing and analysis validated that the device design (i.e., user interface) and labeling are sufficient for appropriate use by intended users of the Pixel 3 System (see Table 2). Human factors assessments were used to modify the user interface to promote reasonably safe and effective use of the Pixel 3 System.

Table 2: Summary of Pixel 3 System Human Factors/Usability Study

Name of Study	Pixel 3 Usability Study (SW 02089)		
Study Objective	The study explores tasks associated with the use of Pixel 3 that may be confusing or difficult for users based on initial testing and feedback as well as tasks that have been identified in the Hazard Analysis as being a potential source of misinterpretation or subject to judgment.		
Subject Population	Subjects are registered nurses who make preparations for an operation and continually monitor the patient and staff during its course, who work in the operating room outside the sterile field in which the operation takes place, and who record the progress of the operation, account for the instruments, and handle specimens (commonly known as a circulating nurse).		
Study Design	Single-center study with two separate arms; one arm focused on live case use and one are focused on simulated use.		
Enrollment	(b)(4) live surgical case evaluations were completed and 8 simulated task based evaluations were completed. A nurse could participate only once in each arm of the study. Cases enrolled included general surgery, obstetrics, orthopedics, and other specialties. The specific case procedure type and categorization of blood loss per type for the live cases is detailed in the table below.		
	Procedure Type	Number of Cases	Blood Loss Category
	Cesarean Section	(b)(4) Trade Secret/CCI 46%	High
	Cesarean Section – Simple	8%	Medium
	Open Reduction Internal Fixation Femur	8%	Low

	Open Reduction Internal Fixation Ankle Myomectomy/Hysterectomy Abdominal Myomectomy, Total Abdominal Hysterectomy Total	(b)(4) Trade Secret/CCI	15% 8% 15% 100%	Low Medium Medium High 6, Medium 4, Low 3
Study Procedure	<ul style="list-style-type: none"> ▪ For the simulated use arm, the test equipment was set-up in an operating room without a patient present per the Instructions for Use (IFU). The simulated case evaluations were conducted as task based scenarios. In each case use scenario, the circulating nurse was observed performing specific tasks with the Pixel 3 System. The test moderator did not interfere with the process. Each task implemented a specific pass or fail criteria, and users were allowed two attempts at each task. If the user could not complete the task after two attempts, the specific task was recorded as a fail. The specific tasks evaluated included pairing the Bluetooth foot pedal to the iPad, assigning sponges to foot pedals, orienting the iPad correctly to prepare it for scanning, ambient lighting indicator recognition, entering a Hb value on the Monitoring screen, scanning a sponge within the bounding box, Hb mass is greater than approved range indicator recognition, deleting a scanned sponge and duplicate sponge, reading sEBL from the user interface, reviewing scans and verifying sponge count prior to closing the case, and closing the case. ▪ For the live case use arm, the test equipment was set-up in an operating room per the IFU prior to the patient entering the room. Users were trained per the IFU approximately one to two weeks prior to use. During the case, the circulating nurse was observed scanning soiled surgical sponges into the Pixel 3 System and user comments and/or observations were noted as appropriate. The test moderator did not interfere with the process. The study device was not utilized to provide any clinical information during surgical cases. ▪ At the completion of the simulated or live use, the circulating nurses provided feedback in three ways: <ol style="list-style-type: none"> 1. Completed a 15 item questionnaire that evaluated usability of various tasks with the Pixel 3 System, scored using 1 to 5 Likert scale with 1=difficult and 5=easy. 2. Addressed three questions with binary (yes/no) responses regarding aspects of safety related to the use of Pixel 3. 3. Provided open-ended answers at the end of the questionnaire about different tasks. 			
Endpoints/Results	<ul style="list-style-type: none"> ▪ All eight (8) users in the simulated cases were able to successfully complete the tasks per the protocol pass/fail criteria. Ninety-four (94%) of tasks were completed during the first pass and 100% of tasks were completed during the second pass. In the yes/no responses, all questions received a positive response. No users thought that the Pixel 3 posed any potential safety issues to either the nursing staff or patients. ▪ Likert scores were between a high of 4.92 and a low of 4.04 for questions addressed after live case use. The average for all responses was 4.57. All answers for the binary (yes/no) responses were positive except one. The single negative response, regarding nurse safety, was noted by a user who stated that if the user didn't have access to eye protection that a sponge might be too close to the face. The same user also recommended that the screen be lowered so that the scanning doesn't cover the user's face. Therefore, it was determined by the sponsor that the iPad may have been 			

set-up too high for that user.

SUMMARY OF CLINICAL STUDIES

The sponsor conducted two clinical studies with the Pixel 3 System: (1) preliminary clinical testing (Study 1, 46 patients, 758 sponges) and (2) confirmatory clinical testing (Study 2, 50 patients, 791 sponges).

PRELIMINARY CLINICAL TESTING (STUDY 1)

Following IRB approval, forty-six patients undergoing surgery with anticipated significant blood loss contributed laparotomy sponges for Hb loss estimation using the Pixel 3 System in a prospective, multi-center study. A total of 46 surgical procedures at three (3) clinical sites between July and November 2012 contributed a total of 758 laparotomy sponges (18 in x 18 in, from Cardinal Health, RFDetect, and AMD Ritmed) for analysis. Of these, 167 sponges were analyzed on a per-sponge basis whereas the remaining 591 sponges were analyzed in batches. Pre-operative hemoglobin level (g/dl) was recorded for all but 7 subjects. The mean (\pm SD) of preoperative Hb was 12.9 \pm 1.5 g/dl. The mean (\pm SD) laparotomy sponge count per case was 17 \pm 10. The mean fluid volume (\pm SD) contained on sponges per case was 668 \pm 455 ml. Cases enrolled included gynecology, obstetrics, orthopedics, urology, and general surgery, without regard for the type of procedures. The Pixel 3 system was used to capture scans of surgical laparotomy sponges following the final sponge count at the conclusion of each surgical procedure. The Hb mass loss estimated by the Pixel 3 System (sHbL) was compared to Hb loss measured by a mechanical extraction method (assay sHbL). Accuracy was evaluated using linear regression and Bland-Altman analysis. In addition, the Pixel 3 System's calculation of blood volume loss on sponges (sEBL) was compared with the gravimetric method of estimating blood loss from sponge weights. A significant positive linear correlation ($r = 0.93$ [95% CI 0.88 to 0.96]) was noted between the Pixel 3 estimates of cumulative sHbL per case and a cumulative measure of Hb mass obtained from sponges by rinsing and photometric assay of the effluent (reference method). Bland-Altman analysis revealed a bias of 9.0 g Hb per patient between the two methods. The corresponding lower and upper limits of agreement were -7.5 g and 25.5 g per case, compared to the reference method. The sHbL estimation bias of the Pixel 3 system in this study (9.0 g Hb) would be equivalent to roughly 63 ml of allogeneic whole blood from a donor with a laboratory-derived Hb level between 13-15 g/dl. Mean estimated blood loss on sponges using the Pixel 3 system was more accurate than the gravimetric method, which overestimated the Pixel 3 System's estimate by 359 ml per patient (627 ml vs. 268 ml, $p < 0.0001$). Estimates of blood loss using the gravimetric method may be confounded by the presence of non-sanguineous fluids on the sponges (e.g., saline irrigation), whereas the Pixel 3 estimates of blood loss (sEBL) are not.

In the preliminary clinical study (Study 1), a subset of cases (12 of 46) were evaluated using per-sponge estimates, ($n=167$ sponges). In this subset of cases, three sponges (1.8% of the 167 sponges collected) exceeded the validated range of Hb mass (greater than approximately 6 g Hb per sponge). Sponges from the remaining cases in Study 1 (34 of 46, $n=591$ sponges) were assayed in batches and were excluded from this analysis.

CONFIRMATORY CLINICAL TESTING (STUDY 2)

Following IRB approval, fifty patients undergoing elective surgery and caesarean delivery contributed laparotomy sponges for Hb loss estimation in a prospective accuracy study. A total of 50 surgical procedures contributed a total of 791 laparotomy sponges (18in x 18in, RFDetect laparotomy sponges) for analysis. Enrollment was initiated in July 2013 and continued through October 2013 at one (1) clinical site. Preoperative hemoglobin level (g/dl) was recorded for each subject whose case data (sponges) were collected for analysis in this study. Mean (\pm SD) of preoperative Hb was 12.0 (\pm 1.6) g/dl and ranged from 7.6 g/dl to 15.5 g/dl. The mean (\pm SD) sponge count per case was 16 (\pm 6) and ranged from 8 to 33 sponges per case. The mean fluid volume contained on sponges per case was 667 (\pm 353) ml. Cases enrolled included gynecology, obstetrics, orthopedics, urology, and other specialties without regard for the type of procedures. The Pixel 3 system was used “live” (intra-operatively) to capture scans of surgical laparotomy sponges as they were removed from the surgical field and counted. The Hb mass loss estimated by the Pixel 3 System (sHbL) was compared to Hb loss measured by the same reference method used in the prior clinical study. Accuracy of total sHbL per patient, and cumulative sHbL across intra-operative intervals was evaluated using linear regression methods and Bland-Altman analysis. A significant positive linear correlation between the Pixel 3 system and the reference method (rinsing and photometric assay of the effluent) was sustained across the four intervals ($r = 0.92, 0.90, 0.91, 0.91, p < 0.0001$, respectively). Across the intervals, bias of cumulative sHbL (g) increased monotonically from 0.1 g (Interval 1, first 25% of sponges scanned) to 3.7 (Interval 4, End of case). The corresponding lower and upper limits of agreement drifted from -4.9 g (Interval 1) to -15.3 g (End of case) and 5.2 g (Interval 1) to 22.7 g (End of case), respectively, when compared to the reference method. The overall sHbL estimation bias of the Pixel 3 System in this study (3.7 g Hb, end of case) would be equivalent to roughly 26 ml of allogeneic whole blood from a donor with a laboratory-derived Hb level between 13-15 g/dl. In clinical testing, the Pixel 3 System’s sEBL (end of case) also displayed a consistently lower variance and higher precision than the visual (single-rater) estimates by the anesthesiologist and gravimetric (weighing sponges) methods of estimating blood loss (Figure 1). Estimates of blood loss using the gravimetric method may be confounded by the presence of non-sanguineous fluids on the sponges (e.g., saline irrigation), whereas the Pixel 3 estimates of blood loss (sEBL) are not.

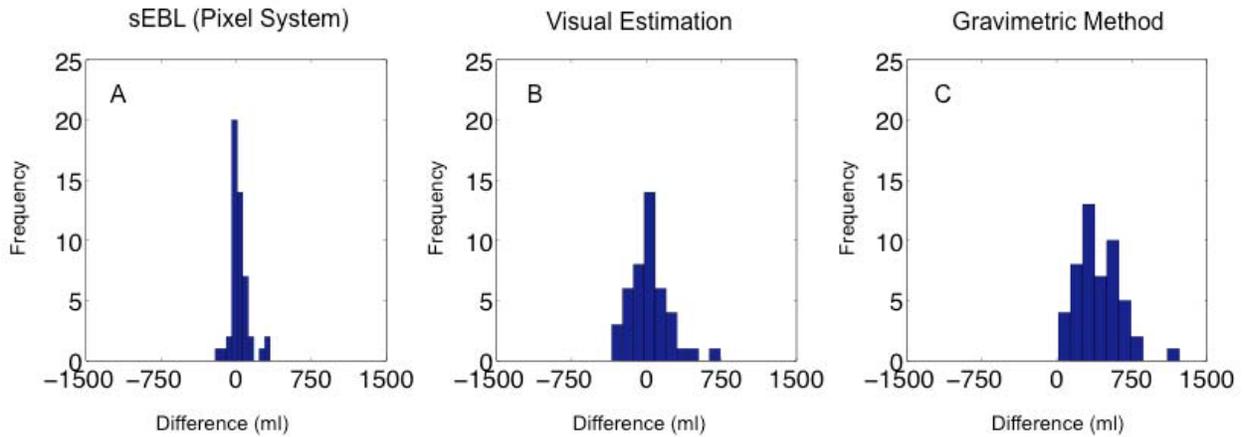


Figure 1: Precision comparison of the Pixel 3 System’s calculation of cumulative sEBL per case with onsite methods of assessing blood loss on sponges (visual estimation, B, and gravimetric method, C). Plots represent the distribution of differences between each method and the assay sEBL (reference standard).

In the second confirmatory clinical study, which comprised a random sampling of 791 lap sponges, all individually assayed, across 50 procedures, 29 sponges (3.6% of the 791 sponges) exceeded the validated range of Hb mass (greater than approximately 6 g Hb per sponge).

LABELING

Labeling has been provided which includes the instructions for use and an appropriate prescription statement as required by 21 CFR 801.109.

The labeling includes the following information:

- Warnings, cautions, and limitations needed for safe use of the device
- A detailed summary of the performance testing pertinent to use of the device, including a description of the bias and variance the device exhibited during testing.
- The validated surgical materials, range of hemoglobin mass, software, hardware, and accessories that the device is intended to be used with
- EMC and wireless technology instructions and information

RISKS TO HEALTH

Table 3 below identifies the risks to health that may be associated with use of an image processing device for estimation of external blood loss and the measures necessary to mitigate these risks.

Table 3: Identified risks to health and mitigation measures.

Identified Risk	Mitigation Method
Failure to Provide Accurate or Precise Device Output	Non-clinical Performance Testing Software Display of Estimated Cumulative Error Software Verification, Validation, and Hazard

	Analysis Human Factors Testing Labeling
Use Error	Human Factors Testing Labeling
Electromagnetic Incompatibility	Electromagnetic Compatibility Testing Wireless Testing Labeling

SPECIAL CONTROLS :

In combination with the general controls of the Food, Drug & Cosmetic Act, the **Image processing device for estimation of external blood loss** is subject to the following special controls:

1. Non-clinical performance data must demonstrate that the device performs as intended under anticipated conditions of use. Demonstration of the performance characteristics must include a comparison to a scientifically valid alternative method for measuring deposited hemoglobin mass. The following use conditions must be tested:
 - A. Lighting conditions;
 - B. Range of expected hemoglobin concentrations;
 - C. Range of expected blood volume absorption; and
 - D. Presence of other non-sanguineous fluids (e.g., saline irrigation fluid)
2. Human factors testing and analysis must validate that the device design and labeling are sufficient for appropriate use by intended users of the device.
3. Appropriate analysis and non-clinical testing must validate the electromagnetic compatibility (EMC) and wireless performance of the device.
4. Appropriate software verification, validation and hazard analysis must be performed.
5. Software display must include an estimate of the cumulative error associated with estimated blood loss values.
6. Labeling must include:
 - A. Warnings, cautions, and limitations needed for safe use of the device;
 - B. A detailed summary of the performance testing pertinent to use of the device, including a description of the bias and variance the device exhibited during testing;

- C. The validated surgical materials, range of hemoglobin mass, software, hardware, and accessories that the device is intended to be used with; and
- D. EMC and wireless technology instructions, information, and precautions

BENEFIT/RISK DETERMINATION

There are three features of the device and the benefits of each feature are given below separately. The device risks are discussed as a whole.

SPONGE COUNTING DEVICE FEATURE

A retained surgical sponge in a patient is a recognized medical “never event” that has potential catastrophic implications for patients. While the overall incidence of retained surgical sponges is low particularly in operations where the procedure is not performed in an open cavity, when there is a retained sponge it causes unnecessary patient morbidity.

The benefit of the device as an adjunctive tool for sponge counts may be to provide additional assurances of accountability (e.g., to help prevent the rare circumstance of a patient having a retained surgical sponge).

ESTIMATED BLOOD LOSS COLLECTED ON A VALIDATED SPONGE DEVICE FEATURE

Current visual methods for estimating blood loss on surgical sponges is severely limited by human error and gravimetric methods for estimating blood loss are time consuming and uncommonly performed. The gravimetric method may be further biased by additional fluids such as saline on the sponges. A fast and consistent method for estimating blood collected on surgical sponges may cause more attention to be given to estimated blood loss so that such estimates can better inform current methods for determining the need for intravenous fluid and blood replacement therapy.

Through bench and clinical studies, it was determined that as multiple sponges are used during an operation the cumulative error associated with the total estimated blood volume on all sponges used during an operation would increase. While no limit on the acceptable amount of cumulative error was determined, the cumulative error will be displayed along with the Pixel 3 System device output in order to inform the healthcare provider of the accuracy associated with the total sHbL and sEBL by sHbL outputs.

If used in accordance with the proposed labeling, the Pixel 3 System can provide benefit as an adjunct method, with higher consistency/precision, to visual and gravimetric methods for the assessment of blood loss on sponges that have been validated for use with the Pixel 3 System.

COLLECTION OF INPUTTED INFORMATION

This device feature may improve work processes associated with capturing of inputted information regarding estimated blood loss on non-validated sponges and transfusion volumes of packed red blood cells, fresh frozen plasma, and platelets.

The Pixel 3 System risks (listed below) may be associated with under- or over-estimation of blood loss. The likelihood for each of these risks has not been quantified, but are expected to be low to moderate given the steps taken through the bench testing, clinical testing, human factors/usability testing, device design and labeling provided to mitigate each of the listed Pixel 3 System device risks.

PIXEL 3 DEVICE RISKS

Failure to provide accurate or precise device output:

- Inaccurate sponge counts
- Inaccurate or imprecise estimates of blood volume collected on validated surgical sponges
- Inaccurate or imprecise estimates of fluid volume collected on non-validated surgical sponges, calculated from user-entered information of sponge weights
- Inaccurate capture of volumes of transfused blood products

Use error

Electromagnetic incompatibility

The probable benefits of the Pixel 3 System include that the device provides a mobile, real-time aid for the estimation of blood loss that is an alternative to the gravimetric and visual assessment methods that are currently utilized.

In conclusion, given the available information above, the data support that as an aid in the estimation of blood loss, the probable benefits outweigh the probable risks for the Pixel 3 System. Sufficient evidence has been provided to establish special controls that can adequately mitigate the risks to health for the intended use of the Pixel 3 System.

CONCLUSION

The *de novo* for the Pixel 3 System is granted and the device is classified under the following:

Product Code: PBZ

Device Type: Image processing device for estimation of external blood loss

Class: II

Regulation: 21 CFR 880.2750