September 9, 2023

Brainlab AG
Esther Moreno Garcia
QM Consultant
Olof-Palme-Str.9
Munich, 81829
Germany

Re: K223864
Trade/Device Name: Alignment System Cranial, Alignment Software Cranial, Cirq Alignment Software Cranial Biopsy, Cirq Alignment Software Cranial sEEG, Varioguide Alignment Software Cranial
Regulation Number: 21 CFR 882.4560
Regulation Name: Stereotaxic Instrument
Regulatory Class: Class II
Product Code: HAW
Dated: August 10, 2023
Received: August 10, 2023

Dear Esther Moreno Garcia:

We have reviewed your Section 510(k) premarket notification of intent to market the device referenced above and have determined the device is substantially equivalent (for the indications for use stated in the enclosure) to legally marketed predicate devices marketed in interstate commerce prior to May 28, 1976, the enactment date of the Medical Device Amendments, or to devices that have been reclassified in accordance with the provisions of the Federal Food, Drug, and Cosmetic Act (Act) that do not require approval of a premarket approval application (PMA). You may, therefore, market the device, subject to the general controls provisions of the Act. Although this letter refers to your product as a device, please be aware that some cleared products may instead be combination products. The 510(k) Premarket Notification Database located at https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfpmn/pmn.cfm identifies combination product submissions. The general controls provisions of the Act include requirements for annual registration, listing of devices, good manufacturing practice, labeling, and prohibitions against misbranding and adulteration. Please note: CDRH does not evaluate information related to contract liability warranties. We remind you, however, that device labeling must be truthful and not misleading.

If your device is classified (see above) into either class II (Special Controls) or class III (PMA), it may be subject to additional controls. Existing major regulations affecting your device can be found in the Code of Federal Regulations, Title 21, Parts 800 to 898. In addition, FDA may publish further announcements concerning your device in the Federal Register.

Please be advised that FDA's issuance of a substantial equivalence determination does not mean that FDA has made a determination that your device complies with other requirements of the Act or any Federal

statutes and regulations administered by other Federal agencies. You must comply with all the Act's requirements, including, but not limited to: registration and listing (21 CFR Part 807); labeling (21 CFR Part 801); medical device reporting (reporting of medical device-related adverse events) (21 CFR 803) for devices or postmarketing safety reporting (21 CFR 4, Subpart B) for combination products (see https://www.fda.gov/combination-products/guidance-regulatory-information/postmarketing-safety-reporting-combination-products); good manufacturing practice requirements as set forth in the quality systems (QS) regulation (21 CFR Part 820) for devices or current good manufacturing practices (21 CFR 4, Subpart A) for combination products; and, if applicable, the electronic product radiation control provisions (Sections 531-542 of the Act); 21 CFR 1000-1050.

Also, please note the regulation entitled, "Misbranding by reference to premarket notification" (21 CFR Part 807.97). For questions regarding the reporting of adverse events under the MDR regulation (21 CFR Part 803), please go to https://www.fda.gov/medical-devices/medical-device-safety/medical-device-reporting-mdr-how-report-medical-device-problems.

For comprehensive regulatory information about medical devices and radiation-emitting products, including information about labeling regulations, please see Device Advice (https://www.fda.gov/medical-devices/device-advice-comprehensive-regulatory-assistance) and CDRH Learn (https://www.fda.gov/training-and-continuing-education/cdrh-learn). Additionally, you may contact the Division of Industry and Consumer Education (DICE) to ask a question about a specific regulatory topic. See the DICE website (https://www.fda.gov/medical-devices/device-advice-comprehensive-regulatory-assistance/contact-us-division-industry-and-consumer-education-dice) for more information or contact DICE by email (DICE@fda.hhs.gov) or phone (1-800-638-2041 or 301-796-7100).

Sincerely,

Adam D. Pierce -S
Digitally signed by Adam D. Pierce -S
Date: 2023.09.09 09:08:17 -04'00'

Adam D. Pierce, Ph.D.
Assistant Director
DHT5A: Division of Neurosurgical,
Neurointerventional
and Neurodiagnostic Devices
OHT5: Office of Neurological
and Physical Medicine Devices
Office of Product Evaluation and Quality
Center for Devices and Radiological Health

Enclosure

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Food and Drug Administration

Indications for Use

Form Approved: OMB No. 0910-0120
Expiration Date: 06/30/2023
See PRA Statement below.

510(k) Number *(if known)*
K223864

Device Name
Alignment System Cranial; Alignment Software Cranial;
Cirq Alignment Software Cranial Biopsy; Cirq Alignment Software Cranial sEEG;
Varioguide Alignment Software Cranial

Indications for Use *(Describe)*
Alignment System Cranial is intended to support the surgeon to plan and to achieve a trajectory with surgical instruments during cranial stereotactic procedures.

The indications for use are biopsy of intracranial lesions and placement of stereoelectroencephalography (SEEG) electrodes.

Type of Use *(Select one or both, as applicable)*

☒ Prescription Use (Part 21 CFR 801 Subpart D) ☐ Over-The-Counter Use (21 CFR 801 Subpart C)

CONTINUE ON A SEPARATE PAGE IF NEEDED.

This section applies only to requirements of the Paperwork Reduction Act of 1995.

DO NOT SEND YOUR COMPLETED FORM TO THE PRA STAFF EMAIL ADDRESS BELOW.

The burden time for this collection of information is estimated to average 79 hours per response, including the time to review instructions, search existing data sources, gather and maintain the data needed and complete and review the collection of information. Send comments regarding this burden estimate or any other aspect of this information collection, including suggestions for reducing this burden, to:

Department of Health and Human Services
Food and Drug Administration
Office of Chief Information Officer
Paperwork Reduction Act (PRA) Staff
PRAStaff@fda.hhs.gov

"An agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB number."

BRAINLAB

510(k) Summary

August 10, 2023

General Information	
Manufacturer	Brainlab AG; Olof-Palme-Str.9, 81829, Munich, Germany
Establishment Registration	8043933
Trade Name	Alignment System Cranial Alignment Software Cranial Cirq Alignment Software Cranial Biopsy Cirq Alignment Software Cranial sEEG Varioguide Alignment Software Cranial
Classification Name	Neurological Stereotaxic Instrument
Product Code	HAW
Regulation Number	882.4560
Regulatory Class	Class II
Panel	Neurology
Predicate Device(s)	Primary Predicate: K191597 Stealth Autoguide System Secondary Predicate: K210989 Cirq Robotic Alignment System Third Predicate: K192703 Cranial Image Guided Surgery System

Contact Information	
Primary Contact	**Alternate Contact**
Esther Moreno Garcia QM Consultant – Regulatory Affairs Phone: +49 89 99 15 68 0 Email: regulatory.affairs@brainlab.com	Chiara Cunico Phone: +49 89 99 15 68 0 Fax: +49 89 99 15 68 5033 Email: chiara.cunico@brainlab.com

1. **Indication for Use**

   Alignment System Cranial is intended to support the surgeon to plan and to achieve a trajectory with surgical instruments during cranial stereotactic procedures.

   The indications for use are biopsy of intracranial lesions and placement of stereo-electroencephalography (SEEG) electrodes.

2. **Device Description**

   The subject device Alignment System Cranial is an image guided surgery system intended to support the surgeon to plan and to achieve a trajectory with surgical instruments during cranial stereotactic procedures using optical tracking technology.

For this purpose, the Alignment System Cranial consists of a combination of hardware and software. The Alignment Software Cranial with its sw components is installed on an Image Guided Surgery (IGS) platform (Curve, Curve Navigation 17700, Kick 2 Navigation Station or Buzz Navigation) consisting of a computer unit, a touch display and an infrared tracking camera. During surgery, the subject device tracks the position of instruments in relation to the patient anatomy and identifies this position on pre- or intraoperative images. The position of the surgical instruments is continuously updated on these images by optical tracking. This position information is used by the Alignment Software Cranial to align either passive or active positioning devices to a planned trajectory for subsequent surgical steps.

The Alignment System Cranial has different configurations of hardware devices depending on which positioning device is used and which indication is performed. The Alignment Software Cranial 2.0 supports the active positioning devices Surgical Base System 1.4 and Cirq Arm System 2.0 (+ Cirq Robotic Alignment Module + Cirq Robotic Disposable Kinematic Unit) as well as the passive positioning device Varioguide. Both types of positioning devices consist of articulated arms with different joints where additional devices and surgical instruments can be attached to for further robotic or manual alignment respectively to a defined trajectory.

In addition, the subject device offers a set of indication specific instruments to support biopsy and sEEG procedures. This instrumentation consists of instrument holders, tracking arrays, guide tubes, reduction tube, bone anchors, drill bits and depth stops. None of the instruments is delivered sterile. All patient contacting materials consist of different alloys of stainless steel.

With this submission, an already existing feature is now performed introducing a new algorithm using artificial intelligence and machine learning (AI/ML). This ML based functionality is used as an aid in the registration step (in surface matching) by allowing a pre-registration based on guide points which are delivered by this algorithm. This pre-registration step is not mandatory. The AI/ML algorithm is a Convolutional Neuronal Network (CNN) developed using a Supervised Learning approach. The algorithm was developed using a controlled internal process that defines activities from the inspection of input data to the training and verification of the algorithm. The training process begins with the model observing, learning, and optimizing its parameters based on the training pool data. The model's prediction and performance are then evaluated against the test pool. The test pool data is set aside at the beginning of the project. This is a static algorithm (locked).

The Alignment Software Cranial has the following accessories:

- Automatic Registration providing an automatic registration for subsequent use.
- Automatic Registration iMRI providing an automatic image registration for intraoperatively acquired MR images.

3. Substantial Equivalence

COMPARISON OF TECHNOLOGICAL CHARACTERISTICS WITH THE PREDICATE DEVICE

Characteristic	Primary Predicate K191597	Secondary Predicate K210989	Third Predicate K192703	Subject device
Indications for use	The Stealth Autoguide System is a positioning and guidance system intended for the spatial positioning and orientation of instrument holders or tool guides to be used by neurosurgeons to guide standard neurosurgical instruments, based on a pre-operative plan and feedback from an image-guided navigation system with three-dimensional imaging software. The Stealth Autoguide System is a remotely-operated positioning and guidance system, indicated for any neurological condition in which the use of stereotactic surgery may be appropriate (for example, stereotactic biopsy, stereotactic EEG, laser tissue ablation, etc.).	The Cirq Robotic Alignment Module is an intraoperative robotic positioning system and an accessory to compatible Brainlab IGS Cranial software applications. Using spatial information from an image guided navigation system, the Cirq Robotic Alignment Module enables the surgeon to align and hold surgical instruments according to pre-planned trajectories. The Cirq Robotic Alignment Module is indicated for stereotactic biopsies of intracranial lesions	The Cranial IGS System, when used with a compatible navigation platform and compatible instrument accessories, is intended as an image-guided planning and navigation system to enable navigated surgery. It links instruments to a virtual computer image space on patient image data that is being processed by the navigation platform. The system is indicated for any medical condition in which a reference to a rigid anatomical structure can be identified relative to images (CT, CTA, X-Ray, MR, MRA and ultrasound) of the anatomy, including among others: Cranial biopsies	Alignment System Cranial is intended to support the surgeon to plan and to achieve a trajectory with surgical instruments during cranial stereotactic procedures. The medical indications for use are biopsy of intracranial lesions and placement of stereo-electroencephalography (SEEG) electrodes.
Localization technique	Optical markers on tool holder	Infrared tracking camera is recognizing infrared passive markers	Infrared tracking camera is recognizing infrared passive markers	Same

		Instrument tracking in relation to the patients anatomy.	Instrument tracking in relation to the patients anatomy.	
System accuracy	Under representative worst case configuration: Mean navigation accuracy of ±2 mm and angular axis displacement of ±2°	Under representative worst case configuration: Mean navigation accuracy of ±2 mm and angular axis displacement of ±2°	Under representative worst case configuration: Mean navigation accuracy of ±2 mm and angular axis displacement of ±2°	Same
Operating principle	Preoperative images (StealthStation) Surgical planning (StealthStation) Patient registration Guidance of instruments Trajectory alignment	Preoperative images Surgical planning Patient registration Guidance of instruments Trajectory alignment with Cirq Arm System plus Cirq Robotic Alignment Module	Preoperative images Surgical planning Patient registration Guidance of instruments Trajectory alignment with VarioGuide	Same Subject device supports alignment with both VarioGuide or with Cirq Arm System plus Cirq Robotic Alignment Module
Planning software	Compatible with: S8 Cranial v1.1 Synergy Cranial v.3.1	Compatible with: Cranial 3.1 Trajectory 2.5	Compatible with: Cranial 3.1 Trajectory 2.5	Same In addition, Intra-op trajectory planning feature added to Alignment Software Cranial
Alignment Instrumentation	Navigated Trajectory Guide Tool Holders (Drill Guides, Reducing Tubes) Height Guides Tapping Tube	Cirq Arm System: Instrument Holder Cranial + Tracking Array Cranial (Navigation and holding) Cranial Drill Bit + Depth Stop (Safe drilling) Biopsy minimally invasive: Guide Tube + Bone Anchor (Holding and guiding of drill)	VarioGuide: Biopsy with burr hole: Compatible disc set (Biopsy needle guidance)	Similar Alignment instrumentation is generally used in all devices with a combination of holders, guides and tubes. Instrumentation has been extended to support new sEEG indication.
Instrument fixation	Special tool holders for different applications mounted to the Stealth AutoGuide	Cirq Robotic Disposable Kinematic Unit to which instrument holder is attached	Disc sets are mechanically connected to the VarioGuide assembly depending on guiding diameter	Mechanical connection is used in all devices for instrument fixation. Identical to predicate 2 and 3.

Alignment process	Fine alignment robotically performed by Autoguide	Rough alignment: Manual positioning of Cirq Arm System with Autopilot feature (Alignment Software) close to final position Fine alignment: Robotic movement of Cirq Robotic Alignment Module	Rough and fine alignment by manual positioning of VarioGuide along planned trajectory with Autopilot feature (Cranial Navigation)	Similar alignment process as Predicate 1 and identical to Predicates 2 and 3.
Patient Registration	Optical Registration Device (via StealthStation)	Optical registration from Cranial 3.1 Methods: Surface matching, landmark registration Surface matching: No pre-registration available.	Optical registration (Registration 3.5) Methods: Surface matching, landmark registration. Surface matching: Detection of anatomical landmarks in pre-registration based on an atlas of the human anatomy.	Optical registration (Registration 3.6). Same registration methods as in Brainlab predicates. Compared to Predicate 3, overall functionality is the same, but landmarks (used for pre-registration) are delivered by an AI/ML based method. Testing demonstrated there are no concerns regarding safety and effectiveness.
IGS Platforms	StealthStation surgical navigation platform consisting of computer, touch monitor and stereotactic camera.	Curve, Kick and Buzz Navigation models are used, consisting of computer, touch monitor and IR camera.	Curve, Kick and Buzz Navigation models are used, consisting of computer, touch monitor and IR camera.	Similar to predicates. Modified platforms (Kick 2 Navigation Station and Buzz Navigation) and new platform model (Curve Navigation 17700) but with overall same components and operating principle.

4. Performance Data

The following testing was conducted on the Subject Device to establish substantial equivalence with the predicate devices:

Software Verification and Validation Testing
Software verification and validation testing were conducted and documentation was provided as recommended by FDA's Guidance for Industry and FDA Staff, "Guidance for the Content of Premarket Submissions for Software Contained in Medical Devices." This included product specifications, risk analysis or incremental test strategies. The software for this device was considered as a "major" level of concern.

For the landmark detection feature in the pre-registration step now implemented using AI/ML, performance testing comparing conventional to machine learning based landmark detection was performed showing equivalent performance as in the third predicate device.

Usability Evaluation
Summative usability was carried out according to the standard IEC 62366-1 "Medical devices – Part 1: Application of usability engineering to medical devices" in a simulated clinical environment to validate the new use scenarios: Varioguide for biopsy and Cirq for sEEG workflows. This covered aspects such as the guidance provided by the updated Alignment Software Cranial, the handling of instruments or the assembly of the positioning devices with overall focus on new or changed features. The final designs were proven safe and effective for use in the defined use scenarios.

System accuracy testing
The positional and angular navigation accuracy for biopsy and sEEG procedures of the Subject Device including the software, the platforms, the positioning devices and the instruments was evaluated considering a realistic clinical setup and representative worst case scenarios. The results show the following acceptance criteria are fulfilled:

- Mean Positional Error of the placed instrument's tip ≤ 2 mm
- Mean Angular Error of the placed instrument's axis ≤ 2°

Therefore, the Subject Device achieves the same accuracy performance as the three predicate devices considered.

Electrical safety and electromagnetic compatibility (EMC)
Compliance to electrical safety, RFID and EMC was evaluated on the Subject device according to the standards: IEC 60601-1, AIM 7351731 and IEC 60601-1-2. The tests have shown that the subject device performs as intended.

Instruments

BRAINLAB

Instruments verification included:

- Biocompatibility assessment considering the materials used in the devices, manufacturing, processing, biological and chemical test data, and the history of safety and effectiveness of the device materials in contact with the human body.
- Cleaning and disinfection evaluation/reprocessing validation.
- Mechanical properties of instruments by performing life cycle simulations and verification of clearance fits, material fatigue, functionality, etc.
- Stability performance testing was performed in selected worst case situations for the drill bits to ensure they can withstand the loads they might be exposed to during use.

No clinical testing was needed for the Subject Device since optical tracking technology in the scope of image guided surgery for the included indications for use is well established in the market.

5. Conclusion

The comparison of the Subject Device with the predicate devices shows that the Alignment System Cranial has similar functionality, intended use and technological characteristics as the predicate devices. Based on the comparison to the predicates and the performance testing conducted, the Subject Device is considered substantially equivalent to the predicate devices.