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Orthopedic Non-Spinal Bone Plates, Screws, and Washers - Premarket Notification (510(k)) Submissions

Draft Guidance for Industry and Food and Drug Administration Staff

DRAFT GUIDANCE

This draft guidance document is being distributed for comment purposes only.

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You should submit comments and suggestions regarding this draft document within 60 days of publication in the *Federal Register* of the notice announcing the availability of the draft guidance. Submit electronic comments to http://www.regulations.gov. Submit written comments to the Dockets Management Staff, Food and Drug Administration, 5630 Fishers Lane, Room 1061, (HFA-305), Rockville, MD 20852-1740. Identify all comments with the docket number listed in the notice of availability that publishes in the *Federal Register*.

For questions regarding this document, contact OHT6: Office of Orthopedic Devices/DHT6C: Division of Restorative, Repair and Trauma Devices at (301) 796-5650.

U.S. Department of Health and Human Services
Food and Drug Administration
Center for Devices and Radiological Health

Preface

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Orthopedic Non-Spinal Bone Plates, Screws, and Washers - Premarket Notification (510(k)) Submissions

Draft Guidance for Industry and Food and Drug Administration Staff

This draft guidance, when finalized, will represent the current thinking of the Food and Drug Administration (FDA or Agency) on this topic. It does not establish any rights for any person and is not binding on FDA or the public. You can use an alternative approach if it satisfies the requirements of the applicable statutes and regulations. To discuss an alternative approach, contact the FDA staff or Office responsible for this guidance as listed on the title page.

I. Introduction

This draft guidance document provides recommendations for premarket notification (510(k)) submissions for non-resorbable bone plate, screw, and washer devices. These devices are indicated for orthopedic bone fixation and exclude indications for spinal, mandibular, maxillofacial, cranial, and orbital fracture fixation.

For the current edition of the FDA-recognized consensus standard(s) referenced in this document, see the FDA Recognized Consensus Standards Database.[1] For more information regarding use of consensus standards in regulatory submissions, please refer to the FDA guidance titled "Appropriate Use of Voluntary Consensus Standards in Premarket Submissions for Medical Devices."[2]

In general, FDA's guidance documents do not establish legally enforceable responsibilities. Instead, guidances describe the Agency's current thinking on a topic and should be viewed only as recommendations, unless specific regulatory or statutory requirements are cited. The use of the word *should* in Agency guidances means that something is suggested or recommended, but not required.

[1] Available at https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfStandards/search.cfm.

[2] Available at https://www.fda.gov/regulatory-information/search-fda-guidance-documents/appropriate-use-voluntary-consensus-standards-premarket-submissions-medical-devices.

II. Background

Non-spinal, non-resorbable bone plates, screws and washers are implants intended for bone fixation. These are class II medical devices for which the safety and effectiveness are well-established. This guidance is intended to facilitate consistency in information provided in submissions by addressing common deficiencies related to device description and performance testing and by identifying applicable cross-cutting guidances and consensus standards. Certain orthopedic non-spinal metallic bone screws and washers under product codes HTN and HWC and non-spinal bone plates under product code HRS (see Section III. Scope below for more information) may also be appropriate for submission of a 510(k) through the Safety and Performance Based Pathway.[3] For more information, refer to FDA's guidance entitled "Orthopedic Non-Spinal Metallic Bone Screws and Washers - Performance Criteria for Safety and Performance Based Pathway"[4] and "Orthopedic Fracture Fixation Plates - Performance Criteria for Safety and Performance Based Pathway."[5]

This document supplements other FDA documents regarding the specific content requirements of a premarket notification (510(k)) submission. You should also refer to 21 CFR 807.87, 21 CFR 814.20 and FDA's guidance, "Format for Traditional and Abbreviated 510(k)s."[6]

III. Scope

The scope of this document is limited to class II, orthopedic, non-resorbable, non-spinal bone plate and screw systems, stand-alone bone screws, and associated washers. These devices are regulated under 21 CFR 888.3030 and 21 CFR 888.3040 with the product codes listed in the table below:

Table 1 – Relevant Product Codes

Product Code	Regulation Number	Name
HRS	21 CFR 888.3030	Plate, Fixation, Bone
HWC	21 CFR 888.3040	Screw, Fixation, Bone
HTN	21 CFR 888.3030	Washer, Bolt Nut
NDG	21 CFR 888.3030	Washer, Bolt, Nut, Non-Spinal, Metallic

Devices that fall within the scope of this guidance document are comprised of non-resorbable metallic or polymeric components such as, but not limited to, those manufactured from:

[3] See https://www.fda.gov/regulatory-information/search-fda-guidance-documents/safety-and-performance-based-pathway.

[4] https://www.fda.gov/regulatory-information/search-fda-guidance-documents/orthopedic-non-spinal-metallic-bone-screws-and-washers-performance-criteria-safety-and-performance.

[5] https://www.fda.gov/regulatory-information/search-fda-guidance-documents/orthopedic-fracture-fixation-plates-performance-criteria-safety-and-performance-based-pathway

[6] https://www.fda.gov/regulatory-information/search-fda-guidance-documents/format-traditional-and-abbreviated-510ks-guidance-industry-and-fda-staff.

- titanium alloy (e.g., per ASTM F136 *Standard Specification for Wrought Titanium-6Aluminum-4Vanadium ELI (Extra Low Interstitial) Alloy for Surgical Implant Applications (UNS R56401)* or ASTM F1295 *Standard Specification for Wrought Titanium-6Aluminum-7Niobium Alloy for Surgical Implant Applications (UNS R56700)*),
- commercially pure titanium (e.g., per ASTM F67 *Standard Specification for Unalloyed Titanium, for Surgical Implant Applications (UNS R50250, UNS R50400, UNS R50550, UNS R50700)),*
- stainless steel (e.g., per ASTM F138 *Standard Specification for Wrought 18Chromium-14Nickel-2.5Molybdenum Stainless Steel Bar and Wire for Surgical Implants (UNS S31673)*),
- cobalt-chrome alloy (e.g., per ASTM F1537 *Standard Specification for Wrought Cobalt-28Chromium-6Molybdenum Alloys for Surgical Implants (UNS R31537, UNS R31538, and UNS R31539))*,
- polyetheretherketone (PEEK) (e.g., per ASTM F2026 *Standard Specification for Polyetheretherketone (PEEK) Polymers for Surgical Implant Applications*), or
- chopped carbon fiber reinforced (CFR) PEEK (e.g., per ASTM F3333 *Standard Specification for Chopped Carbon Fiber Reinforced (CFR) Polyetheretherketone (PEEK) Polymers for Surgical Implant Applications*).

This guidance document does not specifically address non-spinal bone plate, screw, and washer devices with the following characteristics:

- nitinol devices,
- coated devices,
- devices with surface modifications,
- devices incorporating antimicrobial agents,
- devices with complex geometries,
- devices with differing modularities,
- devices with unique geometric features,
- devices that utilize unconventional surgical techniques (e.g., those that differ from open reduction and internal fixation),
- resorbable devices,
- additively manufactured devices, or
- devices possessing other unique technological characteristics.

If any of the above characteristics pertain to your device, we recommend submitting a Pre-Submission to obtain Agency feedback. For further information regarding the Q-Submission Program, refer to "Requests for Feedback and Meetings for Medical Device Submissions: The Q-Submission Program."[7]

In addition, this guidance document does not address the following device types:

[7] https://www.fda.gov/regulatory-information/search-fda-guidance-documents/requests-feedback-and-meetings-medical-device-submissions-q-submission-program.

- Bone plates and screws that are intended for mandibular, maxillofacial, cranial, and orbital fracture fixation;
- Bone plates and screws that are intended for use in the spine and suture anchors; and
- Fixation components that are part of a bone anchor tightrope (bone-to-bone or soft tissue-to-bone), such as those used for reinforcing ankle syndesmosis or correcting bunion angular deformities.

IV. Premarket Submission Recommendations

A. Indications for Use

For each subject device, the intended use(s)/indications(s) should be stated, and a comparison of the intended use/indications for use to one or more legally marketed predicate device(s) should be included in your submission. Please note that differences in indications for use (e.g., disease condition, patient population) may prompt a request for additional information to support the new indication.[8]

Examples of uses that have been cleared for these types of 510(k)s include:

- long bone fracture fixation[9]
- small bone fracture fixation[10]
- small bone fragment fixation
- fracture fixation of specific anatomical locations (e.g., femur, tibia, fibula, clavicle, humerus, olecranon)
- arthrodesis of a joint or osteotomy of the small bones
- as components of specific cerclage systems

We recommend that the indication for use statements for these devices, avoid vague language (e.g., "bone fixation," "small bones") to help reduce ambiguity and clarify appropriate device use. Additionally, 510(k) submissions involving any spinal or non-orthopedic uses should be submitted in a separate 510(k) submission to the appropriate review group or Office of Health Technology.

If seeking an indication for use in osteopenic bone, comparison should be made to one or more legally marketed predicate device(s) intended for use in the same anatomical location with

[8] Within the 510(k) paradigm, any change in indications for use that raises different questions of safety and effectiveness and therefore precludes a meaningful comparison with the predicate device constitutes a new intended use and would be deemed "not substantially equivalent" to the predicate device. See also FDA's guidance "The 510(k) Program: Evaluating Substantial Equivalence in Premarket Notifications [510(k)]," available at https://www.fda.gov/regulatory-information/search-fda-guidance-documents/510k-program-evaluating-substantial-equivalence-premarket-notifications-510k.

[9] The term "long bone" refers to fracture fixation of the femur, tibia, fibula, humerus, ulna, and radius.

[10] The term "small bone" refers to fracture fixation of the wrist, hand, and foot.

similar indications. If seeking indications for osteoporotic bones or "poor bone quality"[11] (e.g., lower bone mineral density (BMD) attributable to Type I diabetes mellitus), additional information may be requested to demonstrate performance of the implant in the simulated use and bone condition to support the indications for use.

For bone plates or screws with pediatric indications, you should identify the pediatric subpopulations that the devices are intended to treat. Refer to the guidance document entitled "Premarket Assessment of Pediatric Medical Devices"[12] for more information.

B. Device Description

We recommend you identify your device by the applicable regulation number and product code indicated in Section III above and include the information described below.

For bone plates and screws, we recommend that you provide images of the device and the following system level overview information in tabular format, for example, as shown in Table 2:

Table 2 – General System Descriptive Information

System Description	Subject Device (Examples)
Intended use	*Fracture fixation; joint arthrodesis*
Product code	*HRS*
Target population	*Adults only; pediatrics; adults and pediatrics*
Anatomical site(s) of use	*Long bones; proximal humerus; Tarsometarsophalenageal joint*
Provided sterile/non-sterile	*Provided non-sterile; Provided sterile*
Sterilization method	*Steam; gamma irradiation*
Shelf life	*N/A; 2 years*
Packaging (if provided sterile)	*N/A*
System components that can be reprocessed and, if so, are cleaning	*All instruments, cleaning instructions included in the Instructions for Use*

[11] Bone quality refers to those structural and material properties of bone that determine its biomechanical behavior in ways that are not accounted for by bone quantity or mass. For orthopedic devices, FDA defines the term "poor bone quality" as impaired bone strength (biomechanical performance) sufficient to increase fracture risk or hardware failure that is not accounted for by measured bone density.

[12] https://www.fda.gov/regulatory-information/search-fda-guidance-documents/premarket-assessment-pediatric-medical-devices.

instructions included and location within submission	
Summary of how the device achieves its intended function	*Bone plates are used in conjunction with compatible bone screws to create a stabilized construct that promotes fracture healing. The system contains locking and nonlocking screws. Screw holes and screw head design allow variable angle placement within a 15 degree cone.*

The submission should include a table with the name of each component in the system with its associated part number. Descriptive information for each component should include critical dimensions for the entire range of available sizes in tabular format. Examples of recommended information to include and example format for critical dimensions for bone plates, bone screws, and washers/bolt nuts are provided in Tables 3, 4, and 5 below. For submissions that include multiple designs or device types, a separate table for each design or device type should be included in the device description section with the information as outlined below. For any FDA-recognized consensus standards referenced in these tables, we recommend you specifically state the edition of the standard that was used.

For each plate design you should include the information found in Table 3.

Table 3 – Plate Descriptive Information

Plate Description	**Subject Device (Examples)**
Representative image or photograph of component	
Anatomical site of use	*Long bone diaphysis; long bone epiphysis;*
Materials	*Ti-6Al-4V titanium alloy; Cobalt-Chrome*
Any standards to which the materials conform	*ASTM F136; ASTM F1537*
General plate shape	*T-plate; straight plate*
Number of holes	*X number of holes*
Hole dimensions	*Y mm hole diameter*
Locking mechanism, if applicable	*Non-locking*

Plate Description	**Subject Device (Examples)**
Screw angle placement ability relative to plate	*Orthogonal placement; fixed angle placement; variable angle placement in a 15 degree polyaxial cone for locking screws only*
Plate width range (minimum and maximum in the structurally critical region)	*A – B mm*
Plate length range	*C – D mm*
Plate thickness range (minimum and maximum in the structurally critical region)	*E – F mm*
Previously cleared compatible screws	*2.7mm screws lengths 10mm – 30mm; 510(k) number(s)*
New proposed compatible screw sizes	*3.0mm diameter cortical screws and 4.5mm cancellous screws in lengths 8mm – 40mm.*
Compatible screw features	*Locking, 10 degree variable angle locking screws*

For each screw design you should include the information found in Table 4.

Table 4 – Stand-Alone Screw Descriptive Information

Screw Description	**Subject Device (Examples)**
Representative image or photograph of component	
Materials	*316L Stainless Steel; CP Ti Grade 4*
Any standards to which the materials conform	*ASTM F138; ASTM F67*
Type of screw	*Cortical; Snap-off*
If cannulated, cannula diameter	*A mm diameter*
Screw length range	*B – C mm*
Length of threaded region range	*D – E mm*
Minor screw diameter range	*F – G mm*
Major screw diameter range	*H – I mm*
Thread pitch range	*J – K mm*

For each washer/bolt nut design you should include the information found in Table 5.

Table 5 – Washer Descriptive Information

Washer/Bolt Nut Description	**Subject Device (Examples)**
Representative image or photograph of component	
Materials	*316L Stainless Steel*
Any standards to which the materials conform	*ASTM F138*
Inner diameter range	*A – B mm*
Outer diameter range	*C – D mm*
Thickness range	*E – F mm*
Previously cleared compatible screws	*510(k) number(s)*
New proposed compatible screws	*Subject screw diameters in mm*

You should submit engineering drawings for each size and part number that include critical dimensions and tolerances. Alternatively, you should supply representative drawings with a table of each part number that includes critical dimensions, as follows, for each size:

- Plates: plate angulation (if applicable), minimum and maximum length, minimum and maximum width in the structurally critical region, minimum and maximum thickness in structurally critical region, screw hole diameter, and distance between screw holes.

- Screws: minimum and maximum length, threaded diameter, core diameter, axial thread length, thread pitch, screw head diameter, height, and thread feature if applicable.

For devices incorporating embedded fibers, such as carbon fiber reinforced PEEK (CFR PEEK), the following material parameters should be included in the device description: percent fiber used, length of fibers (average and distribution), fiber direction, and sizing agent used (for interfacial adhesion between fiber and polymer). These parameters may impact the conditions under which delamination between fiber and matrix occurs, which could impact device performance. This is further discussed in Section IV.J below.

If the device is provided with surgical instrumentation, the instruments should also be identified in the submission, along with the associated classification regulation(s). For example, many instruments that are for general use and can be used in any generic orthopedic bone plate or screw implantation procedure, are regulated under 21 CFR 878.4800 Manual surgical instrument for general use or 21 CFR 888.4540 Orthopedic manual surgical instrument. These instruments are considered class I and are exempt from 510(k) review. Descriptive information, as shown in

Table 6, for class II, device-specific instruments[13] should be included in the device description section of your submission.

Table 6 – Device-Specific Instrument Descriptive Information

Instrumentation Description	**Subject Instrument (Examples)**
Name of the instrument and part number	*Snap-off screwdriver; Volar plate head drill guide block*
510(k) number if instrument has been previously cleared	*New instrument*
Representative engineering drawing(s), schematic, illustration, photograph and/or figure	*See section X, page Y for engineering drawing*
Purpose and brief description of the instrument	*Intended to interact specifically with the handle of the screw to allow removal upon clockwise twisting of the driver after the screw is fully seated; Intended to guide screw placement directly into unique screw hole pattern on the head of the plate*
Statement clarifying if the instrument is single-use or reusable	*Reusable; single-use*
Provided sterile/non-sterile	*Non-sterile; sterile*
Sterilization method	*Steam; Ethylene oxide*
Materials	*PEEK, Stainless steel*
Any standards or material specifications to which the materials conform	*Master file number; ASTM F899*
Duration of contact with the patient	*Transient contacting during screw insertion; limited contact for the entire duration of surgery*

[13] A device-specific orthopedic instrument is considered to be an accessory designed specifically for appropriate implantation or placement of the parent device, based upon unique dimensions, geometry, and/or deployment. See 84 FR 14865.

Instrumentation Description	Subject Instrument (Examples)
Color additives, if included in patient contacting components	*Blue color additive X in the handle; red color additive Z in the implant*

C. Predicate Comparison

For devices reviewed under the 510(k) process, manufacturers should compare their new device to a similar legally marketed predicate device to support its substantial equivalence ((section 513(i) of the Federal Food, Drug, and Cosmetic Act (FD&C Act); 21 CFR 807.87(f))))) unless utilizing the optional approach identified in the FDA guidance "Safety and Performance Based Pathway."[14] (See "Orthopedic Non-Spinal Metallic Bone Screws and Washers - Performance Criteria for Safety and Performance Based Pathway"[15] and "Orthopedic Fracture Fixation Plates - Performance Criteria for Safety and Performance Based Pathway"[16]). This comparison should provide information to show how your device is similar to and different from the predicate. Side by side comparisons, whenever possible, are desirable. See Tables 7, 8, 9, and 10 below for examples of how this information can be organized. These tables are not intended to represent an exhaustive list of comparative parameters; ensure you provide all relevant device descriptive characteristics as outlined in Section IV.B, above. The predicate device comparison section of your submission should also include a discussion of why any differences in technological characteristics identified in the table(s) below do not raise different safety and effectiveness questions, and how the subject device is substantially equivalent to the predicate(s).

Table 7 – Predicate Comparison General Descriptive Information

System Characteristics	Subject Device	Primary Predicate	Additional Predicate
Intended use	*Arthrodesis and fracture fixation*	*Arthrodesis*	*Fracture fixation*
Classification/Product code			
Target population	*Adults*		
Anatomical site of use	*Foot*	*Mid foot*	*Forefoot*
Provided sterile/non-sterile			
Sterilization method			
Shelf life			
Packaging			

[14] https://www.fda.gov/regulatory-information/search-fda-guidance-documents/safety-and-performance-based-pathway.
[15] https://www.fda.gov/regulatory-information/search-fda-guidance-documents/orthopedic-non-spinal-metallic-bone-screws-and-washers-performance-criteria-safety-and-performance.
[16] https://www.fda.gov/regulatory-information/search-fda-guidance-documents/orthopedic-fracture-fixation-plates-performance-criteria-safety-and-performance-based-pathway.

227 **Table 8 – Predicate Comparison Plate Descriptive Information**
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Plate Description	Subject Device	Primary Predicate	Additional Predicate
Representative image or photograph of component			
Anatomical site of use	*Proximal humerus*	*Humerus*	*Long bones*
Materials	*CP Ti Grade 4*	*Stainless steel*	
Any standards to which the materials conform	*ASTM F67*	*ASTM F138*	
General plate shapes	*Anatomic specific*	*Straight plate*	
Number of holes	*12*	*8*	
Hole dimensions	*5.2mm diameter holes*	*6mm diameter holes*	
Locking mechanism if applicable	*Locking screws mate directly with threads on the plate*	*Non-locking*	*Locking caps*
Screw placement trajectory	*Fixed angle locking screws; non-locking screws inserted in a 10 degree polyaxial cone*	*orthogonal*	*Fixed angle non-locking*
Plate width range	*8mm – 30mm*	*8mm – 12mm*	
Plate length range	*50mm – 150mm*	*80mm*	
Plate thickness range	*3mm – 3.5mm*	*2.5mm*	
Compatible screw sizes	*3.5mm*	*4.0mm*	*3.5mm*
Compatible screw types	*Locking, non-locking*	*Variable angle locking screw*	

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230 **Table 9 – Predicate Comparison Stand-Alone Screw Descriptive Information**
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Screw Description	Subject Device	Primary Predicate	Additional Predicate
Representative image or photograph of component			
Materials	*Stainless steel*	*Ti-6Al-4V titanium alloy; Cobalt-Chrome*	
Any standards to which the materials conform	*ASTM F138*	*ASTM F136; ASTM F1537*	
Type of screw	*Headless screw*	*Cancellous screw*	*Snap-off screw*
If cannulated: cannula diameter	*1.5mm*		
Screw length range	*8mm – 60mm*		

Screw Description	Subject Device	Primary Predicate	Additional Predicate
Length of threaded region range	*5mm – 50mm*		
Minor screw diameter range	*2.5mm*		
Major screw diameter range	*3.5mm*	*3.2mm*	
Thread pitch range	*1.0mm*	*1.25mm*	

Table 10 – Predicate Comparison Washer Descriptive Information

Washer/Bolt Nut Description	Subject Device	Primary Predicate	Additional Predicate
Representative image or photograph of component			
Materials	*CP Ti Grade 4*	*Stainless steel*	
Any standards to which the materials conform	*ASTM F67*	*ASTM F138*	
Inner diameter range	*3mm – 6mm*		
Outer diameter range	*5mm – 10mm*		
Thickness	*0.5mm*		
Compatible screws	*2.7mm – 7.5mm*		

- The materials used for bone plates and bone screws impact the mechanical performance of these devices. If your plate and/or screw components are manufactured from different materials than the predicates you have identified, or use different manufacturing methods or processing steps, additional material characterization may be requested, such as fatigue performance of the plate, or mechanical evaluations of the plate/screw interface. We recommend you submit a Pre-Submission to discuss the testing plans with FDA. For more information about Pre-Submissions and the Q-Submission program, refer to the FDA guidance document entitled "Requests for Feedback on and Meetings for Medical Device Submissions: The Q-Submission Program."[17]

- Metallic fracture fixation hardware components that are generally in contact with components made of dissimilar metals may result in galvanic corrosion. Additionally, novel materials may raise questions regarding corrosion in that corrosion may cause premature failure of the device and adverse biological reactions. If your plate or screw system contains metallic components that are different from the predicate device, or if the combination of metals in the subject system is different or has known susceptibility to corrosion (e.g., connections of nitinol and stainless steel components), additional information may be necessary to demonstrate that corrosion susceptibility over the entire surface of the final finished device and interfacing components is equal to or less than that measured in a legally marketed device with the same intended use. ASTM F2129 *Standard Test Method for Conducting Cyclic Potentiodynamic Polarization*

[17] https://www.fda.gov/regulatory-information/search-fda-guidance-documents/requests-feedback-and-meetings-medical-device-submissions-q-submission-program.

Measurements to Determine the Corrosion Susceptibility of Small Implant Devices may be appropriate to analyze corrosion susceptibility of your device. We recommend you submit a Pre-Submission to discuss the testing plans with FDA. For more information about Pre-Submissions and the Q-Submission program, refer to the guidance "Requests for Feedback and Meetings for Medical Device Submissions: The Q-Submission Program."[18]

D. Labeling

The premarket notification must include proposed labeling in sufficient detail to satisfy the requirements of 21 CFR 807.87(e). Proposed labels and labeling, sufficient to describe the bone plates, screws, and washers, their intended use, and the directions for use should be provided.

As prescription devices, bone plates, screws, and washers are exempt from having adequate directions for use under section 502(f)(1) of the Federal Food, Drug and Cosmetic Act (FD&C Act)) as long as the conditions in 21 CFR 801.109 are met. For instance, labeling should include adequate information for practitioner use of the device, including indications, effects, routes, methods, frequency and duration of administration and any relevant hazards, contraindications, side effects and precautions. (21 CFR 801.109(d)).

In addition to requirements in 21 CFR part 801, labeling should include the following information:

- Device description (including material and sterility status);
- Device use (including single-use/reusable, intended users or specific patient populations);
- Contraindications (e.g., active infection, inability to comply with post-operative weight bearing instructions, inadequate bone stock or poor blood supply)
- Warnings (e.g., not to use the device across an active growth plate for devices indicated for pediatric use);
- MR safety information (refer to Section J);
- Cleaning and sterilization instructions, if applicable (refer to Sections E and F); and
- Removal instructions (particularly for devices indicated for pediatric use).

Additionally, since plating systems can contain many different plate types and components for creating a fracture fixation construct, we recommend that you provide information in the labeling to aid the surgeon in proper construct selection (e.g., material labeling for plates of the identical geometry or comparative performance information).

For plate(s) made of anisotropic materials, if the submission includes labeling that instructs users to contour plates to fit varying patient anatomies, we recommend also including in the 510(k)

[18] https://www.fda.gov/regulatory-information/search-fda-guidance-documents/requests-feedback-and-meetings-medical-device-submissions-q-submission-program.

submission testing and/or justification demonstrating that the plate(s) maintains adequate strength following such bending. This is further discussed in Section IV.K.1 below.

E. Sterility

Significance: Bone plates, screws, washers, and patient contacting instrumentation should be adequately sterilized to minimize infections and related complications.

Recommendation: For bone plates, screws, and washers, and instruments labeled as sterile, we recommend that you provide information for the finished device in accordance with FDA's guidance "Submission and Review of Sterility Information in Premarket Notification (510(k)) Submissions for Devices Labeled as Sterile."[19]

F. Reprocessing (including single-use devices provided non-sterile and intended for sterile processing)

Significance: Many of the patient contacting instruments associated with bone plates, screws, and washers are reused, and should be adequately cleaned and sterilized between uses to minimize infections and prevent device degradation. Bone plates, screws, and washers can also be single-use medical devices initially supplied as non-sterile to the user and necessitate the user to process (clean and sterilize) the device prior to its use.

Cleaning instructions in the labeling should clearly identify their applicability for reprocessing soiled reusable instruments or their applicability to new and uncontaminated implants and instruments prior to sterilization.

Recommendation: Instructions on how to reprocess a reusable device or process a single-use device that is provided non-sterile to the user are critical to ensure that a device is appropriately prepared for its initial and/or subsequent uses and should be included in the labeling.

Instructions for cleaning should be designed and validated for the type of contamination anticipated on the device, based on its intended use. Accordingly, there may be separate, dedicated cleaning instructions; for new, uncontaminated single-use devices prior to sterilization, as well as separate, dedicated instructions for routine cleaning of contaminated reusable medical instruments prior to sterilization. Single-use devices such as implants, should be cleaned separately from soiled reusable devices to prevent cross contamination.

The removal of all residues of manufacturing materials such as lubricants, oils, particulates, and other debris should occur during the manufacturing process, as part of Good Manufacturing Practices (see 21 CFR Part 820). Additionally, health care facilities are unlikely to have the capacity, materials, or adequately trained personnel to remove residues of manufacturing materials from medical devices. Validated cleaning steps should be performed for removing manufacturing contaminants from your implants at the site of manufacture, in accordance with the Quality System Regulation, 21 CFR 820.70(h).

[19] https://www.fda.gov/regulatory-information/search-fda-guidance-documents/submission-and-review-sterility-information-premarket-notification-510k-submissions-devices-labeled.

For recommendations regarding the development and validation of reprocessing parameters and the reprocessing instructions in your proposed device labeling, refer to FDA's guidance "Reprocessing Medical Devices in Health Care Settings: Validation Methods and Labeling."[20]

The following list includes some additional considerations for reprocessing instructions that are included in the labeling for bone plates, screws, and washers provided non-sterile to the end user:

- Final rinse water quality should include specifications qualified for the device's intended use. For example, Critical Water, as currently defined by AAMI TIR34: *Water for the Reprocessing of Medical Devices*, is recommended to address various concerns for implantable devices.

- We recommend that the labeling include a statement to warn against use of devices that may have become damaged or contaminated. For example: "*If the device has become damaged or contaminated, it should NOT be reprocessed and should be properly disposed of.*"

  If the labeling instructs the end user to reprocess (sterilize, or clean and sterilize) "opened-but-unused" devices, validated instructions (for sterilization, or cleaning and sterilization) should be included in the labeling. In these circumstances, we recommend that labeling designated for "Opened-but-Unused" products include comprehensive instructions that:

  1. explicitly define "contaminated" and characterize the conditions under which a device would be considered "unused."

     Note: FDA considers that:

     - a statement such as "no contamination with body fluids" is not adequate, as not all contamination is necessarily visible;
     - a device which has been introduced to the sterile field, even if "unused," may be contaminated as such items may have been subjected to aerosolized contaminants or other sources of contamination; and
     - all handling should be considered a potential source of contamination.

  2. provide validated reprocessing instructions for "Opened-but-Unused" product that are consistent with definitions as recommended above.

- We recommend that reprocessing validation activities for bone plates, screws, and washers account for the use of sterilization trays, and instructions in the labeling should be consistent with these validation activities (e.g., if trays were not stacked

[20] https://www.fda.gov/regulatory-information/search-fda-guidance-documents/reprocessing-medical-devices-health-care-settings-validation-methods-and-labeling.

during the validation activities, then a "Do Not Stack Trays" warning should be included).

We recommend that information about the sterilization trays be included in the submission for bone plates, screws, and washers. If a third party, general use sterilization tray is utilized, the 510(k) number should be provided. For dedicated sterilization trays that are unique to a particular orthopedic system, adequate device description information should be provided, including an explanation of the tray dimensions, material, and load configuration and contents. If you intend to leverage information from a previously validated worst-case system, you should also include an explanation of how the challenge device is applicable to the subject system, in accordance with FDA-recognized consensus standard, ANSI/AAMI/ISO 17665-1: *Sterilization of health care products – Moist heat – Part 1*.

G. Pyrogenicity

Significance: Pyrogenicity testing is used to help protect patients from the risk of febrile reaction due to gram-negative bacterial endotoxins and/or chemicals that can leach from a medical device (e.g., material-mediated pyrogens).

Recommendation: To address the risks associated with the presence of bacterial endotoxins, bone plates, screws, and washers provided sterile should meet pyrogen limit specifications by following the recommendations outlined in FDA's guidance " Submission and Review of Sterility Information in Premarket Notification (510(k)) Submissions for Devices Labeled as Sterile."[21] You should also follow the recommendations in "Guidance for Industry Pyrogen and Endotoxins Testing: Questions and Answers."[22] To address the risks associated with material-mediated endotoxins, follow the recommendations in FDA's guidance "Use of International Standard ISO-10993-1, 'Biological Evaluation of Medical Devices Part 1: Evaluation and Testing.'"[23]

For devices intended to be labeled as "non-pyrogenic," we recommend that both bacterial endotoxins and material-mediated pyrogens be addressed.

H. Shelf Life and Packaging

Significance: Package shelf life (stability) and package integrity (performance) testing is conducted to support the proposed package shelf life (expiration date) and performance. Testing should also be conducted to evaluate any changes to device performance or functionality.

Recommendation: For devices provided sterile, you should provide a description of the packaging, including how it will maintain the device's sterility, a description of the package

[21] https://www.fda.gov/regulatory-information/search-fda-guidance-documents/submission-and-review-sterility-information-premarket-notification-510k-submissions-devices-labeled.
[22] https://www.fda.gov/regulatory-information/search-fda-guidance-documents/pyrogen-and-endotoxins-testing-questions-and-answers.
[23] https://www.fda.gov/regulatory-information/search-fda-guidance-documents/use-international-standard-iso-10993-1-biological-evaluation-medical-devices-part-1-evaluation-and.

integrity test methods, but not the package integrity test data. We recommend that package integrity test methods include simulated distribution and associated package integrity testing, as well as simulated (and/or real time) aging and associated seal strength testing, to validate package integrity and shelf life claims. We recommend you follow the methods described in ISO 11607-1 *Packaging for terminally sterilized medical devices – Part 1: Requirements for materials, sterile barrier systems and packaging systems* and ISO 11607-2 *Packaging for terminally sterilized medical devices – Part 2: Validation requirements for forming, sealing and assembly processes.*

With respect to evaluating the effects of aging on device performance or functionality, shelf life studies should evaluate the critical physical and mechanical properties of the device to ensure it will perform adequately and consistently during the entire proposed shelf life. To evaluate device functionality, we recommend that you assess each of the bench tests described in Section K and repeat all tests that evaluate design components or characteristics that are potentially affected by aging.

We recommend that you provide a summary of the test methods used for your shelf life testing, results, and the conclusions drawn from your results. If you use devices subject to accelerated aging for shelf life testing, we recommend that you specify the way in which the devices were aged and provide a rationale to explain how the results of shelf life testing, based on accelerated aging, are representative of the results if the device were aged in real time. We recommend that you age your devices as per ASTM F1980 *Standard Guide for Accelerated Aging of Sterile Barrier Systems for Medical Devices* and specify the environmental parameters established to attain the expiration date. For devices or components containing polymeric materials or coatings, you should conduct testing on real-time aged samples to confirm the results of the accelerated aging study. This testing should be conducted in parallel with 510(k) review and clearance, with results documented to file in the design history file (i.e., the complete test reports do not need to be submitted to FDA).

I. Biocompatibility

Significance: Bone plates, screws, washers, and accompanying surgical instrumentation contain patient-contacting materials, which, when used for their intended purpose, (i.e., contact type and duration), may induce a harmful biological response.

Recommendation: You should determine the biocompatibility of all patient-contacting materials present in your device (this includes implants and device-specific instrumentation). If your device(s) in its final finished form is identical in chemical composition, manufacturing, and processing methods, and any differences in geometry or surface properties are not expected to adversely impact the biological response compared to a legally marketed bone plate(s), screw(s), washer(s), or instrument(s) with a history of successful use, you may reference previous testing experience, or the literature, if appropriate. For metallic devices it may be appropriate to reference a recognized consensus standard, while for polymeric devices, a Letter of Authorization (LOA) for a device Master File (MAF) could be provided. You should refer to the following FDA webpage for additional information on using device MAFs: https://www.fda.gov/medical-devices/premarket-approval-pma/master-files. In addition to the

device material information, you should provide information to demonstrate that the subject device is identical to a legally marketed device with respect to manufacturing material formulations, processes, packaging, and sterilization methods (if applicable) in its final finished form. Attachment F of the FDA guidance document, "Use of International Standard ISO 10993-1, 'Biological evaluation of medical devices - Part 1: Evaluation and testing within a risk management process'," [24] includes example documentation language that may be utilized.

If you are unable to identify a legally marketed predicate device with the same nature of contact and contact duration that uses the same materials and manufacturing process as used in your device, we recommend that you conduct and provide a biocompatibility evaluation as recommended in FDA's guidance "Use of International Standard ISO-10993-1, 'Biological evaluation of medical devices - Part 1: Evaluation and testing within a risk management process.'"[25] The evaluation should explain the relationship between the identified biocompatibility risks, the information available to mitigate the identified risks, and any knowledge gaps that remain. You should then identify any biocompatibility testing or other evaluations that were conducted to mitigate any remaining risks. We recommend that you consider the recommendations in this guidance, which identifies the types of biocompatibility assessments that should be considered and recommendations regarding how to conduct related tests.

Per ISO 10993-1 *Biological evaluation of medical devices – Part 1: Evaluation and testing within a risk management process* and Attachment A of FDA's guidance on ISO-10993-1, bone plates, screws, and washers are implant devices in contact with tissue/bone for a permanent contact duration. Therefore, the following endpoints should be addressed in your biocompatibility evaluation:

- cytotoxicity;
- sensitization;
- irritation or intracutaneous reactivity;
- acute systemic toxicity;
- material mediated pyrogenicity;
- subacute/subchronic toxicity;
- genotoxicity;
- implantation;
- chronic toxicity; and
- carcinogenicity.

For device-specific, patient-contacting device instrumentation in contact with tissue/bone for a limited contact duration, the following endpoints should be addressed in your biocompatibility evaluation:

[24] https://www.fda.gov/regulatory-information/search-fda-guidance-documents/use-international-standard-iso-10993-1-biological-evaluation-medical-devices-part-1-evaluation-and.
[25] Ibid.

- cytotoxicity;
- sensitization;
- irritation or intracutaneous reactivity;
- acute systemic toxicity; and
- material mediated pyrogenicity.

J. Magnetic Resonance (MR) Compatibility for Passive Implants

Significance: MR imaging of patients with bone plates, screws, and washers poses the following potential hazards:

- movement of the implant, resulting in tissue damage or displacement of the device;
- heating of the tissue surrounding the implant and subsequent tissue damage; and/or
- image artifacts that may render the MR images uninterpretable or misleading.

Recommendation: We recommend that you address the issues affecting safety and compatibility of your device in the MR environment as described in the FDA guidance "Testing and Labeling Medical Devices for Safety in the Magnetic Resonance (MR) Environment."[26]

For devices anticipated for use in the MR environment that have not been evaluated for safety in the MR environment, we recommend you follow FDA's recommendations in section VIII.D. of the above referenced guidance document.

If you would like to market bone plates, screws, or washers of various sizes and shapes as "MR Conditional," then we recommend you follow our recommendations in the FDA guidance, "Assessment of Radiofrequency-Induced Heating in the Magnetic Resonance (MR) Environment for Multi-Configuration Passive Medical Devices."[27]

K. Non-Clinical Testing

The 510(k) submission should include information to demonstrate that the subject device provides substantially equivalent fixation of a fracture site. We recommend that you conduct the testing recommended below to evaluate the material and performance characteristics of your worst-case device in its final finished form. If your plate, screw, or washer system is indicated for use in multiple anatomical locations or if the system encompasses a large variety of device designs, there may be more than one worst-case device that should be supported with mechanical performance data.

A sample size of five (5) units has historically been accepted as the minimum for bench testing. Additional issues in testing (e.g., large inter-sample variability) or device design may warrant a larger sample size.

[26] https://www.fda.gov/regulatory-information/search-fda-guidance-documents/testing-and-labeling-medical-devices-safety-magnetic-resonance-mr-environment.

[27] https://www.fda.gov/regulatory-information/search-fda-guidance-documents/assessment-radiofrequency-induced-heating-magnetic-resonance-mr-environment-multi-configuration.

For information on the recommended content and format of test reports for the testing described in this section, refer to FDA's guidance, "Recommended Content and Format of Non-Clinical Bench Performance Testing Information in Premarket Submissions."[28]

For the FDA-recognized consensus standards identified below, supplemental documentation to support a Declaration of Conformity is likely necessary as discussed in FDA's guidance, "Appropriate Use of Voluntary Consensus Standards in Premarket Submissions for Medical Devices,"[29] as these standards contain variable methods and do not include acceptance criteria for all testing recommended in this guidance. The supplemental documentation should include the items specified in the report section of each testing annex in the consensus standard (and listed below in Appendices A and B) used to support the premarket submission. Acceptance criteria, if not included in the applicable FDA-recognized consensus standard(s), should be provided with a supporting rationale to justify how the performance testing results support a determination of substantial equivalence. We recommend that you can provide a comparison of the subject device test results to the test results of a legally marketed predicate device with the same intended use, in a tabular format such as the examples in Appendices A and B.

The following sections describe the recommended mechanical performance testing endpoints for bone plates and screws. When a plating system's overall construct and plate designs are similar to the identified predicate, individual analysis of the worst-case plate and screw components as listed below may be sufficient to establish substantial equivalence of the construct. When the overall subject construct differs in fixation method or raises concerns about strength or stability at the fracture site, additional construct evaluations such as bench testing or *in vivo* data may be needed to demonstrate substantial equivalence. Additional endpoints or testing information may be needed depending on the device design and comparison to the predicate device(s). Devices which are made from polymers, metals, or metallic alloys with different properties compared to the identified predicates, especially resorbable materials, may warrant additional performance information such as component interface analysis (e.g., wear, corrosion) or fatigue strength analysis. Technological characteristics that appear to create worse mechanical performance compared to the identified predicates may warrant additional information to demonstrate equivalent fracture fixation in construct strength, construct stiffness and fatigue performance.

Submissions for devices made of anisotropic materials should address shear strength of the devices and risk for crack propagation through additional testing and/or scientific justification. When evaluating a device(s) containing fibers, such as CFR PEEK, device parameters including percent fiber used, length of fibers (average and distribution), fiber direction, and sizing agent (for interfacial adhesion between fiber and polymer) should be taken into consideration as these parameters can impact the mechanical performance of the device. Specific recommendations for plate(s) made of anisotropic materials are discussed in Section VI.K.1 below.

[28] https://www.fda.gov/regulatory-information/search-fda-guidance-documents/recommended-content-and-format-non-clinical-bench-performance-testing-information-premarket.

[29] https://www.fda.gov/regulatory-information/search-fda-guidance-documents/appropriate-use-voluntary-consensus-standards-premarket-submissions-medical-devices.

1. Plate Mechanical Performance

Significance: Loss of fracture reduction or construct stiffness can cause incomplete or absent osteosynthesis leading to device failure and revision surgery. Mechanical performance testing of plates provides assurance of the device's ability to perform as intended.

Recommendation: Single cycle bend testing should be conducted on the worst-case subject plate in the worst-case load bearing region. When assessing the mechanical performance of plates with a worst-case structurally critical region (that can physically fit between the loading rollers of a four-point bend test), we recommend performing testing per ASTM F382 *Standard Specification and Test Method for Metallic Bone Plates*. The worst-case design selection should consider plate thickness, second moment of area, length, and overall shape. Depending on the particular plate geometry and dimensions, modifications to the test setup outlined in ASTM F382, with appropriate justification, could be considered. Outcomes for the single cycle (quasi-static) bend testing should include the bending structural stiffness and the bending strength.

To ensure the test results can be adequately evaluated, we recommend you provide testing information per ASTM F382 for subject and predicate tests in tabular format, identifying any differences in test methods and providing a justification for why these differences do not impact the comparability of results. See Appendix A, Example Table of Plate Test Methods and Data Summary, for an example of how test summary information could be organized.

Plates with similar design features and materials to predicate devices typically do not warrant fatigue bend testing per ASTM F382. However, devices with differences in technological features compared to traditional plating systems (e.g., different material selection, complex designs, plate modularities) may warrant fatigue testing to demonstrate substantial equivalence. Plates with their worst-case structurally critical region present in the uniform portion of the plate shaft are expected to show similar trends when comparing static performance and fatigue performance (if applicable).

If you use an alternative method to ASTM F382, the following should be taken into account when designing the test setup to determine component or construct equivalence: the worst-case clinically relevant loading, clinically relevant loading modes (e.g., axial compression, bending, torsion), differences in material properties, and differences in dimensions and geometry of the subject and predicate devices.

For a plate(s) made of anisotropic materials, if bending/contouring is not explicitly discouraged in the labeling, the submission should include additional testing and/or a scientific justification to confirm the plate(s) is able to maintain mechanical performance following worst-case contouring consistent with the

instructions provided in the labeling and common clinical practice.

2. Screw Mechanical Performance

Significance: Inadequate mechanical performance can cause screws to fracture during insertion or during healing. Torsional strength analysis provides assurance of strength. Loss of fixation can lead to premature failure of the screws or backout causing pain from increased prominence. Pullout strength analysis provides assurance of fixation strength.

Recommendation: When assessing the mechanical performance of screws, we recommend performing 1) insertion/removal torque testing, 2) torsional strength testing, and 3) pullout strength testing per ASTM F543 *Standard Specification and Test Methods for Metallic Medical Bone Screws*. For screws with technological characteristics (e.g., screw thread designs) that conform to FDA-recognized consensus standards (e.g., ASTM F543), an engineering analysis using the thread geometry, based upon the equation described by Chapman, et al,[30] can also be utilized to demonstrate equivalence for pullout strength in lieu of testing.

Insertion/removal torque testing, torsional strength testing, and pullout strength testing should each be conducted on the corresponding worst-case screws. The worst-case design selection should consider critical parameters such as major/minor screw diameters, thread pitch and trailing angles, polar moment of inertia, thread length, flute design. Reported results for torsional strength testing should include the torsional yield strength and maximum load. Reported results for insertion/removal torque testing should include, respectively, the maximum recorded insertion and removal torques. Reported results for pullout testing should include the maximum load recorded during screw pullout. If pullout testing is not physically performed, then insertion and removal torque testing can be leveraged to confirm that the threads are adequately designed and attached to the screw core diameter.

To ensure the test results can be adequately evaluated, we recommend you provide reportable information per ASTM F543 for subject and predicate tests in tabular format, identifying any differences in test methods and providing a justification for why these differences do not impact the comparability of results. See Appendix B of this guidance, Example Table of Screw Test Methods and Data Summary, for an example of how test summary information can be organized.

Screws with traditional characteristics (e.g., fully threaded) and materials (e.g., stainless steel, titanium alloy) as described in the consensus standards referenced in this guidance typically do not warrant additional evaluation beyond the test

[30] Chapman, J. R., et al, Factors Affecting the Pullout Strength of Cancellous Bone Screws. *J Biomech Eng* 1996: 118(3), 391-8. doi:10.1115/1.2796022.)

methods described in ASTM F543. However, screws with differences in technological characteristics compared to traditional screws (e.g., different material selection, complex designs, modularities) may warrant additional static and fatigue testing to demonstrate substantial equivalence. We recommend you refer to ASTM F1264 *Standard Specification and Test Methods for Intramedullary Fixation Devices* for information on fatigue three- or four-point bending evaluation methods for screws.

If you use an alternative method to ASTM F543, the following should be taken into account when designing the test setup: worst-case clinically relevant loading conditions, differences in material properties, and differences in dimensions and geometry of the subject and predicate devices.

3. Computational Modeling and Engineering Analysis

Significance: Computational modeling (e.g., finite element analysis) and engineering analysis (e.g., dimensional comparison and theoretical calculation of mechanical performance based on empirical models) can be used as an alternative to demonstrate that the mechanical behavior of the worst-case subject plates and screws are expected to be equal to or better than the predicate devices.

Recommendation: If computational modeling or engineering analysis is used to address some or all of the endpoints identified in Sections K. 1. and K. 2., modeling should be performed on the worst-case plate(s) and screw(s). Specific subject plate geometries, such as changes in geometries over the plate length, curvatures, and differences in material, can make static and fatigue comparisons difficult to account for in engineering analysis alone. Therefore, we recommend validation testing to confirm the accuracy of your computational modeling, especially for unique design features/components interfaces.

If no physical testing of specimens is conducted, your computational modeling and/or engineering analysis should address all endpoints identified in Sections K. 1. and K. 2. Refer to FDA's guidance "Reporting of Computational Modeling Studies in Medical Device Submissions"[31] for additional details regarding model validation and reporting numerical simulations. Specifically, refer to Subject Matter Appendix II of the referenced guidance for details concerning computational solid mechanics.

An engineering analysis can be used in lieu of bench testing to support substantial equivalence of the yield strength and structural bending stiffness of a plate if the predicate plate dimensions and material properties (modulus and yield strength) are known, and if the predicate plate is manufactured utilizing the same device material and manufacturing materials and processes as the subject device. The

[31] https://www.fda.gov/regulatory-information/search-fda-guidance-documents/reporting-computational-modeling-studies-medical-device-submissions.

second moment of area and material properties at multiple cross-sections for both the subject and predicate plates can be used to calculate the worst-case theoretical structural bending stiffness and yield moment of each plate.

Similarly, for screws, an engineering analysis can be used in lieu of bench testing to support substantial equivalence of a screw's torsional performance if the predicate screw dimensions (e.g., core diameter, cannulation diameter) and material properties (modulus and yield strength) are known and if the predicate screw is manufactured utilizing the same material and manufacturing processes as the subject device.

As referenced above in Section K.2, an engineering analysis based upon the equation described by Chapman, et al, can be used in lieu of testing to evaluate pullout strength of the screw if the predicate screw dimensions are known, and if the material ultimate shear stress (*S*) and failure modes of the bone foam substrate are equivalent between the subject and predicate devices**.** For example, a material ultimate shear stress value of 3.395 MPa can be used to represent 20 pcf bone foam in your analysis. Note that for this analysis to be appropriate, the instrumentation identified in the associated surgical technique manual should allow for close to idealized thread engagement. If this assumption is not accurate for your scenario, then the identified engineering analysis may not be appropriate for the assessment of the subject device.

For all screws, extract the relevant dimensions below (i.e., screw major diameter, screw minor diameter, screw pitch, and axial thread length). These dimensions will be used to quantify thread engagement and calculate the theoretical pullout strengths for the smallest axial thread lengthened screws in the device system using the following equation:

$$Fs = S * A = \{S * L * \pi * Dmajor * TSF\}$$

Fs = predicted shear failure force (N)
S = material ultimate shear stress (MPa)
A = thread shear area (mm^2)
L = axial thread length (mm) including only threads that have the nominal major diameter where complete purchase is expected (e.g., excluding the screw tip) of thread engagement in material
Dmajor = major diameter (mm)
TSF = Thread Shape Factor (dimensionless) = (0.5 + 0.57735 d/p)
d = thread depth (mm) = (Dmajor – Dminor)/2
Dminor = minor (root) diameter (mm)
p = thread pitch (mm)

A justification should be provided to support why the evaluated screws selected are worst case and also for each variable used in the Chapman analysis (e.g., bone

foam per ASTM F1839). Axial pullout performance is heavily influenced by amount of interface and the failure mechanism at the interface with bone foam. Factors such as decreasing outer diameter and decreasing axial thread length may help identify the worst case.

Dimensions used for calculations should be clearly listed for each theoretical outcome. Dimensional values used in this calculation should be consistent with the values listed on the screw engineering drawings.

L. Non-Clinical Animal and/or Clinical Performance Testing

Non-clinical animal studies[32] and/or clinical evidence are generally unnecessary for most bone plates and screws; however, such testing may be requested in situations such as the following:

- indications for use dissimilar from legally marketed devices of the same type;
- new technology, i.e., technology different from that used in legally marketed devices of the same type (e.g., dynamic or flexible fixation systems that differ in stiffness or strength to other predicates), yet does not raise different questions of safety or effectiveness; or
- cases where engineering and/or animal testing raise issues that warrant further evaluation with clinical evidence.

We encourage manufacturers to take advantage of the Q-Submission Program to ensure that the animal study protocol addresses safety concerns and contains elements which are appropriate for a regulatory submission. For example, animal studies to determine a device's safety must be performed under the Good Laboratory Practice (GLP) regulation in 21 CFR Part 58. In addition, if you are proposing to use a non-animal testing method that you believe is suitable, adequate, validated, and feasible, we recommend that you discuss the proposal using the Q-Submission Program. We will consider if such an alternative method could be assessed for equivalency to an animal test method. For details on the Q-Submission Program, refer to the guidance "Requests for Feedback and Meetings for Medical Device Submissions: The Q-Submission Program."[33]

We will consider alternatives to clinical testing when the proposed alternatives are supported by an adequate scientific rationale. If a clinical study is needed to demonstrate substantial equivalence, i.e., conducted prior to obtaining 510(k) clearance of the device, the study must be conducted under the Investigational Device Exemptions (IDE) regulation, 21 CFR Part 812. Generally, we believe bone plates and screws addressed by this guidance document are significant risk devices subject to all requirements of 21 CFR 812. See the FDA Guidance titled,

[32] FDA supports the principles of the "3Rs," to reduce, refine, and replace animal use in testing when feasible. We encourage sponsors to consult with us if they wish to use a non-animal testing method they believe is suitable, adequate, validated, and feasible. We will consider if such an alternative method could be assessed for equivalency to an animal test method.

[33] https://www.fda.gov/regulatory-information/search-fda-guidance-documents/requests-feedback-and-meetings-medical-device-submissions-q-submission-program.

"Significant Risk and Nonsignificant Risk Medical Device Studies."[34] In addition to the requirements of 21 CFR 812, sponsors of such trials should comply with the regulations governing institutional review boards (21 CFR Part 56) and informed consent (21 CFR Part 50).

When data from clinical investigations conducted outside the U.S. are submitted to FDA for these devices, the requirements of 21 CFR 812.28 may apply.[35] 21 CFR 812.28 outlines the conditions for FDA acceptance of clinical data from investigations conducted outside the U.S. when submitted to support premarket submissions. For more information, see the FDA guidance "Acceptance of Clinical Data to Support Medical Device Applications and Submissions: Frequently Asked Questions."[36]

In some cases, "real-world data" (RWD) may be used to support expansion of indications, changes in surgical technique, or changes in design/prominence for a device for which 510(k) clearance has already been obtained. Whether the collection of RWD for a legally-marketed device requires an IDE depends on the particular facts of the situation. Specifically, if a cleared device is being used in the normal course of medical practice, an IDE would likely not be required. For additional information regarding this topic, please refer to the FDA Guidance entitled "Use of Real-World Evidence to Support Regulatory Decision-Making for Medical Devices."[37]

V. Modifications (Devices subject to 510(k))

In accordance with 21 CFR 807.87(a)(3), a device change or modification "that could significantly affect the safety or effectiveness of the device" or represents "a major change or modification in the intended use of the device" requires a new 510(k).[38] The changes or modifications listed below are examples of changes that may require submission of a new

[34] https://www.fda.gov/regulatory-information/search-fda-guidance-documents/significant-risk-and-nonsignificant-risk-medical-device-studies.

[35] This applies to data from clinical investigations that began on or after February 21, 2019, and are submitted to support a premarket submission, including IDEs, premarket approval applications (PMAs), and 510(k)s.

[36] https://www.fda.gov/regulatory-information/search-fda-guidance-documents/acceptance-clinical-data-support-medical-device-applications-and-submissions-frequently-asked.

[37] https://www.fda.gov/regulatory-information/search-fda-guidance-documents/use-real-world-evidence-support-regulatory-decision-making-medical-devices.

[38] Section 3308 of the Food and Drug Omnibus Reform Act of 2022, Title III of Division FF of the Consolidated Appropriations Act, 2023, Pub. L. No. 117-328 ("FDORA"), enacted on December 29, 2022, added section 515C "Predetermined Change Control Plans for Devices" to the FD&C Act (section 515C). Under section 515C, FDA can approve or clear a predetermined change control plan (PCCP) for a device that describes planned changes that may be made to the device and that would otherwise require a supplemental premarket approval application or premarket notification. For example, section 515C provides that a supplemental premarket approval application (section 515C(a)) or a premarket notification (section 515C(b)) is not required for a change to a device if the change is consistent with a PCCP that is approved or cleared by FDA. Section 515C also provides that FDA may require that a PCCP include labeling for safe and effective use of a device as such device changes pursuant to such plan, notification requirements if the device does not function as intended pursuant to such plan, and performance requirements for changes made under the plan. If you are interested in proposing a PCCP in your marketing submission, we encourage you to submit a Pre-Submission to engage in further discussion with CDRH. See FDA's guidance "Requests for Feedback and Meetings for Medical Device Submissions: The Q-Submission Program."

510(k). Note that this list is not exhaustive but provides examples of modifications that are likely to require submission of a new 510(k). For additional details, please see FDA guidance, "Deciding When to Submit a 510(k) for a Change to an Existing Device."[39]

Such changes or modifications include:

- The addition of a thinner or thicker bone plate, or screws with lower pullout strength than a legally marketed predicate device – FDA considers this change to be a significant change in design. These types of changes could significantly affect the safety and effectiveness of the device by introducing a new potential worst-case scenario for some failure modes (e.g., mechanical failure of the plate, pain and irritation from prominence, loss of screw stability).

- A change in sterilization method from "Established Category A" sterilization methods to "Established Category B" or "Novel" sterilization methods – this type of change could significantly affect the safety and effectiveness of the device by introducing a new or increased risk of device contamination. See FDA's guidance "Submission and Review of Sterility Information in Premarket Notification (510(k)) Submissions for Devices Labeled as Sterile"[40] for a discussion of sterilization methods.

- A change in material – a change in material type (except changes from a weaker common metal to a stronger common metal, as discussed below), formulation, chemical composition, or material processing could significantly affect the safety and effectiveness of the device. The change may introduce new or increased biocompatibility concerns or a change in the risks associated with device failure.

- A change in compatibility of system components – this change could significantly affect the safety and effectiveness of the device by introducing a new worst-case scenario for a failure mode or expand the indications for use of a cleared component.

FDA believes that the following modifications would generally not require a new 510(k):

- The addition of a bone plate, screw, or washer of identical design, material, and processing to a legally marketed device, but of an intermediate size because this would not generally introduce new or significantly modified risks or new worst-case failure modes.

- Modification in the sterilization process from one category A method to another category A method as defined in FDA's guidance "Submission and Review of Sterility

[39] https://www.fda.gov/regulatory-information/search-fda-guidance-documents/deciding-when-submit-510k-change-existing-device.
[40] https://www.fda.gov/regulatory-information/search-fda-guidance-documents/submission-and-review-sterility-information-premarket-notification-510k-submissions-devices-labeled.

Information in Premarket Notification (510(k)) Submissions for Devices Labeled as Sterile" (e.g., steam sterilization, gamma irradiation sterilization), if the change in sterilization method can be justified as having no significant deleterious effect on the mechanical or material properties of the device throughout the duration of its shelf life.

- A change in material from a weaker common metal to a stronger common metal which conforms to an FDA recognized standard(s) and has a history of safe use for the same indications (e.g., change in device from commercially pure titanium to stainless steel per ASTM F138 or a change from commercially pure titanium to titanium alloy per ASTM F136) where no new or increased biocompatibility concerns have been introduced.

- A change in compatible screws to include larger diameters within the range of legally marketed screws with the same intended use and anatomical location (e.g., a wrist plating system cleared with 2.0mm screws is modified to also include a 2.7mm diameter screw of the same type), if it can be justified that the larger diameter screw does not introduce changes to the plate interface or other factors affecting worst case.

APPENDIX A
Example Table of Plate Test Methods and Data Summary

Table A.1 – Example summary of test summary information for single cycle bend testing of plates when performed per ASTM F382 *Standard Specification and Test Method for Metallic Bone Plates*. This represents an example of how test summary information may be organized.

	Definition	Worst-Case Subject Device	Predicate (510(k) submission number)
Parameter			
Description of plate	The bone plate thickness, width, length, and shape.		
Catalog or part number	The identifying series of letters and numbers which is designated to the worst-case construct used in testing and corresponds with the associated engineering drawings.		
Plate material (include ASTM or ISO specification if available)	The base material from which the components are manufactured.		
Center span length	The measured distance between the two loading rollers in the test setup.		
Loading span length	The distance between the support roller and the nearest loading roller.		
Loading roller diameter	The diameter of the construct used to load the subject plate.		
Control method (displacement or load)	The method which is used to determine failure of the plate has occurred.		
Displacement or load control rate utilized	The rate at which the applied load or displacement is recorded throughout the test simulation.		
Test termination criteria	The pre-determined displacement or load values which are used to determine the test termination.		
Sample size	The number of samples used.		
Results			

	Definition	Worst-Case Subject Device	Predicate (510(k) submission number)
0.2% offset displacement (mean ± standard deviation)	Permanent deformation equal to 0.2% of the center loading span distance.		
Proof load (mean ± standard deviation)	The maximum applied load prior to plastic deformation of the plate.		
Bending structural stiffness (mean ± standard deviation)	A normalized calculation of the plate resistance to bending deformation which takes into account the test setup.		
Bending strength (mean ± standard deviation)	The stress required to produce a predetermined amount of plastic deformation of the plate, such as a 0.2% offset.		
Description of failure modes	The predetermined criteria for all methods of failure of the plate.		

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APPENDIX B
Example Table of Screw Test Methods and Data Summary

Table B.1 – Example summary of test summary information for axial pullout strength testing of screws when performed per ASTM F543 *Standard Specification and Test Methods for Metallic Medical Bone Screws*. This represents an example of how test summary information may be organized.

	Definition	Worst-Case Subject Device	Predicate
Parameters			
Description of screw	The screw length, cannula size, major and minor thread diameter, threaded length, and pitch.		
Catalog or part number	The identifying series of letters and numbers which is designated to the worst-case construct used in testing and corresponds with the associated engineering drawings.		
Screw material (include ASTM or ISO specification if available)	The base material from which the components are manufactured.		
Pilot hole diameter (if applicable per the surgical technique)	The diameter of the hole which is pre-drilled into the test block into which the screw tip is inserted.		
Description of pilot hole preparation (e.g., is pilot hole pre-tapped or not)	Determination if the pilot hole will require a tap to be inserted into the pilot hole prior to the insertion of the screw.		
Test block material description	The test block Trade Name, material, and density.		
Displacement rate	The rate at which a tensile load is applied to the screw.		

	Definition	Worst-Case Subject Device	Predicate
Final insertion depth	The final depth that the subject screw reaches into the test block after insertion.		
Grip span	The distance between the edge of the gripping structures holding the test block in place.		
Results			
Axial pullout strength (mean ± standard deviation)	The maximum load achieved before the screw releases from the test block.		
Description of the mode of failure	The observed method of failure for the screw upon release from the test block.		

Table B.2 – Example summary of test summary information for insertion and removal torque testing of screws when performed per ASTM F543: *Standard Specification and Test Methods for Metallic Medical Bone Screws*. This represents an example of how test summary information may be organized.

	Definition	Worst-Case Subject Device	Predicate
Parameters			
Description of screw	The screw length, cannula size, major and minor diameter, threaded length, and pitch		
Catalog or part number	The identifying series of letters and numbers which is designated to the worst-case construct used in testing and corresponds with the associated engineering drawings.		

	Definition	Worst-Case Subject Device	Predicate
Screw material (include ASTM or ISO specification if available)	The base material from which the components are manufactured.		
Test block material description	The test block Trade Name, material, and density.		
Number of revolutions	The number of revolutions recorded when applying torsional force.		
Test speed	The rate of insertion/removal torque recorded throughout the test simulation.		
Description of pilot hole preparation (e.g., is pilot hole pre-tapped or not)	Determination if the pilot hole will require a tap to be inserted into the pilot hole prior to the insertion of the screw.		
Axial load	Determination of axial load to insert or remove the screw.		
Final insertion depth	The final depth that the subject screw reaches into the test block after insertion.		
Sample size	The number of samples used.		
Results			

	Definition	Worst-Case Subject Device	Predicate
Insertion/removal torque (mean ± standard deviation)	The amount of torque required to insert/remove the screw from the test block during the initial four revolutions of the screw.		
Description of failure modes	The observed method of failure for the screw upon insertion or release from the test block.		

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885 **Table B.3 – Example summary of test summary information for torsional strength testing**
886 **of screws when performed per ASTM F543: *Standard Specification and Test Methods for***
887 ***Metallic Medical Bone Screws*. This represents an example of how test summary**
888 **information may be organized.**
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	Definition	Worst-Case Subject Device	Predicate
Parameters			
Description of screw	The screw length, cannula size, major and minor diameter, threaded length, and pitch		
Catalog or part number	The identifying series of letters and numbers which is designated to the worst-case construct used in testing and corresponds with the associated engineering drawings.		
Screw material (include ASTM or ISO specification if available)	The base material from which the components are manufactured.		
Grip Length	The length of the screw which is gripped in the test set-up		
Exposed Length	The length of the screw shaft which is exposed to loading		

	Definition	Worst-Case Subject Device	Predicate
Control method (displacement or load)	The method which is used to determine failure of the screw has occurred.		
Displacement or load control rate utilized	The rate at which the applied load or displacement is recorded throughout the test simulation.		
Test termination criteria	The pre-determined displacement or load values which are used to determine the test termination.		
Sample size	The number of samples used.		
Results			
0.2% offset displacement (mean ± standard deviation)	Permanent displacement equal to 0.002 times the test gage section length for the specific test.		
Torsional yield strength (mean ± standard deviation)	The stress required to produce a predetermined amount of plastic deformation of the screw, such as a 0.2% offset.		
Description of failure modes	The predetermined criteria for all methods of failure of the plate.		

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