

FDA Executive Summary

Prepared for the September 8-9, 2020 Meeting of the
Orthopaedic and Rehabilitation Devices Panel

Classification of Cemented Total First
Metatarsophalangeal Joint Implants

Product Code: LZJ (Prosthesis, Toe
(Metatarsophalangeal), Joint, Metal/Polymer, Semi-
Constrained)

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1. Introduction

Per Section 513(b) of the Food, Drug, and Cosmetic Act (the Act), the Food and Drug Administration (FDA) is convening the Orthopaedic and Rehabilitation Devices Panel (the Panel) for the purpose of obtaining recommendations regarding the classification of cemented total first metatarsophalangeal (MTP) joint implants, a pre-amendments device type which remains unclassified. Specifically, the FDA will ask the Panel to provide recommendations regarding the regulatory classification of cemented total first MTP joint implants under product code “LZJ.” The device names and associated product codes are developed by the Center for Devices and Radiological Health (CDRH) in order to identify the generic category of a device for FDA. While most of these product codes are associated with a device classification regulation, some product codes, including “LZJ” remain unclassified.

FDA is holding this panel meeting to obtain input on the risks to health and benefits of metal/polymer semi-constrained toe (metatarsophalangeal) joint prostheses under product code “LZJ.” The Panel will discuss whether metal/polymer semi-constrained toe (metatarsophalangeal) joint prostheses under product code “LZJ” should be classified into Class III (subject to General Controls and Premarket Approval), Class II (subject to General and Special Controls) or Class I (subject only to General Controls). If the Panel believes that classification into Class II is appropriate for metal/polymer semi-constrained toe (metatarsophalangeal) joint prostheses under product code “LZJ,” the Panel will also be asked to discuss appropriate controls that would be necessary to mitigate the risks to health.

1.1 Current Regulatory Pathways

Cemented total first MTP joint implants are a pre-amendment, unclassified device type. This means that this device type was marketed prior to the Medical Device Amendments of 1976 but was not classified by the original classification panels. Currently these devices are being regulated through the 510(k) pathway and are cleared for marketing if their intended use and technological characteristics are “substantially equivalent” to a legally marketed predicate device. Since these devices are unclassified, there is no regulation associated with product code “LZJ.”

1.2 Device Description

A “prosthesis, toe (metatarsophalangeal), joint, metal/polymer, semi-constrained” is a device intended to be implanted to replace the first MTP joint. The device limits translation and rotation in one or more planes via the geometry of its articulating surfaces. It has no linkage across the joint. These devices include prostheses that have a metatarsal component made of alloys, such as Cobalt-Chromium-Molybdenum, and a phalangeal component or components made of alloys, such as titanium alloy (e.g., Ti-6Al-4V), and ultra-high molecular weight polyethylene and is limited to those prostheses intended for use with bone cement.

2. Regulatory History

The first clearance of a cemented total first MTP joint implant via the 510(k) process was based on evidence that a similar device (Richards Medical Great Toe Prosthesis) was in interstate commerce and labeled for a specific intended use prior to passage of the Medical Device Amendments on May 28, 1976. Importantly, the evidence which supported marketing of this device type prior to passage of the Medical Device Amendments was limited to use of this device with cement as the method of fixation. As such, the first 510(k)-cleared device was determined to be substantially equivalent to the Richards Medical Great Toe Prosthesis, but with limitations that clearly state that the device is not intended for use without bone cement as the method of fixation. Since this initial clearance, there have been twelve (12) subsequent clearances for these devices via the 510(k) pathway with bone cement as the method of fixation. Please refer to Table 1 below for a listing of the manufacturers, device names, and associated 510(k) submission numbers for cemented total first MTP joint implant.

Table 1: 510(k) Clearances for cemented total first MTP joint implant

510(K) NUMBER	TRADE NAME	SPONSOR
K132496	ARTHROSURFACE TOEMOTION	ARTHROSURFACE, INC.
K102549	THE ASCENSION MOVEMENT GREAT TOE SYSTEM TOTAL ARTHROPLASTY	ASCENSION ORTHOPEDICS, INC.
K072251	MERETE TOEMOBILE ANATOMICAL GREAT TOE RESURFACING SYSTEM	MERETE MEDICAL GMBH
K950864	GTS GREAT TOE SYSTEM - (METATARSAL COMPONENT WITH POROUS COATING)	ACUMED INC.
K941650	TOTAL TOE SYSTEM II	BIOMET INC.
K924724	KINETIK GREAT TOE SYSTEM	KINETIKOS MEDICAL INC.
K922211	OSTEOMED GREAT TOE SYSTEM	OSTEOMED CORP.
K920446	TOTAL TOE SYSTEM	BIOMET INC.
K920667	GREAT TOE IMPLANT	ACUMED INC.
K911552	ANATOMIC TOE SYSTEM	ORTHOPAEDIC BIOSYSTEMS
K884561	KOENIG TOTAL TOE IMPLANT	DOW CORNING WRIGHT
K863528	DEPUY BICONDYLAR TOE PROSTHESIS	DEPUY, INC.
K860163	DEPUY BICONDYLAR TOE PROSTHESIS	DEPUY, INC.

3. Indications for Use

The Indications for Use (IFU) statement identifies the condition and patient population for which a device should be appropriately used. There is some minor variability in the indications for use for these products, but representative indications for use for metal/polymer semi-constrained toe (metatarsophalangeal joint) prostheses under product code “LZJ” are as follows:

- Intended for reconstruction of painful and/or severely disabled great toe joints. The device is intended for cemented use only. Indications include:
 - Painful degenerative metatarsophalangeal joint change
 - Hallux rigidus stage 3 and 4 (including rheumatoid and osteoarthritis causes of hallux rigidus)
 - Revisions after moderate proximal phalanx resection

4. Clinical Background

4.1 Disease Characteristics

The integrity of the MTP joint may be compromised by a range of conditions such as:

- **Hallux rigidus** - Hallux rigidus is considered to be the end stage of hallux limitus, or a state in which the ability to create motion in the big toe is lost or severely restricted. It may lead to long-term damage of the first MTP joint, and it usually involves erosion of the joint cartilage and the development of osteoarthritis (Zammit, 2010; Lam, 2017), or degenerative joint disease including rheumatoid arthritis.
- **Prior surgical treatment** – The structural integrity of the first MTP joint can be affected by prior forefoot surgery including failed hallux valgus operations or previously failed toe prostheses.

These conditions result in pain, loss of function, and decreased quality of life.

4.2 Patient Outcomes

Patient outcomes following first MTP joint arthroplasty are based on a combination of parameters including pain as measured by Visual Analog Scale for Pain (VAS Pain), functional improvement (e.g., American Orthopedic Foot and Ankle Score (AOFAS)), range of motion, radiographic evidence of device loosening or osteolysis, and complication rate including revision.

4.3 Currently Available Treatments

There are several alternatives for treatment of symptomatic first MTP joint conditions defined by the indications for use described above. Currently available treatment options include:

- **Arthrodesis:** This treatment is considered the standard of care for treatment of hallux rigidus.
- **Arthroplasty:** The potential advantages of joint arthroplasty for hallux rigidus include relief of pain, preservation or restoration of motion, improvement in function, and maintenance of joint stability. There are four types of arthroplasty procedures:
 - **Silastic (Silicon-based):** The Silastic implants are designed to maintain length of the toe and act as a dynamic spacer, which allows the joint to move.

- **Interposition Arthroplasty:** Interposition arthroplasty involves resection of the joint and interposition of various biological materials that maintains joint motion in patients with severe hallux rigidus. Is considered the most effective alternative to fusion (Gross, 2013).
- **Metallic Hemiarthroplasties:** These prostheses are designed for the proximal phalanx and inserted in a press-fit or cemented fashion.
- **Total Joint Replacement:** *These devices replace the MTP joint and are the subject of this classification effort. Please refer to the device description section for a description of these devices. Also, please refer to the literature section for a summary of the clinical experience.*
- **Synthetic Cartilage Replacement Device:** One device, the Cartiva Synthetic Cartilage Implant (P150017) is approved in the United States for use in the treatment of patients with painful degenerative or post-traumatic arthritis (hallux limitus or hallux rigidus) in the first metatarsal phalangeal joint with or without the presence of mild hallux valgus.

5. Literature Review

Two systematic literature reviews were conducted in an effort to gather published information regarding the safety and effectiveness of cemented total first MTP joint implants under product code “LZJ.”

In 2015, an exhaustive search of PubMed, EMBASE and Google Scholar was done. There was no pre-planned cutoff by age of article as the MTP joint implants have been utilized in medical practice with little change in practice or procedures for decades.

The search used 21 combinations of search terms that included:

- (“implant, MTP arthroplasty, hallux rigidus, hallux, hallux valgus, hallux limitus, arthrodesis, cheilectomy, trade names of all FDA-cleared devices, the Richards Medical Great Toe Prosthesis device, metatarsophalangeal implant surgery, repair, and restoration”).

Searches retrieved 1,173 abstracts and/or papers that were reviewed for relevance which yielded 111 unique published references in this review. With the exception of three foreign papers (German, Turkish, Chinese – all with English translations), the original papers were in English and all papers or book chapters were on human experiences.

In 2020, additional exhaustive searches of PubMed and EMBASE were performed which searched articles published between January 1, 2015 and December 31, 2019. The searches were limited to publications in English.

The PubMed search used the following general device and procedure terms and yielded 681 literature references:

- (“metatarsophalangeal arthroplasty” OR “MTP arthroplasty” OR metatarsophalang* OR “toe joint” OR hallux) AND (implant OR implants OR replacement OR retrieval OR explant OR explants OR “joint prosthesis”)

The EMBASE search used the following terms and yielded 1,547 literature references:

- ('metatarsophalangeal arthroplasty' OR 'mtp arthroplasty' OR metatarsophalang* OR 'toe joint' OR hallux) AND ('implant'/exp OR 'implant' OR 'replacement'/exp OR 'explant'/exp OR explant OR 'retrieval'/exp OR retrieval)

Both searches conducted in 2020 included the trade names of all FDA-cleared devices.

An initial search including only general device and procedure related terms resulted in a total of 2,228 articles during the most recent 5-year period. However, a search including manufacturer and anatomic location in PubMed and EMBASE was subsequently conducted. There were no results retrieved using this search strategy within the period January 1, 2015 to December 31, 2019.

Upon further screening, four additional relevant articles were identified which, in addition to the 111 articles identified prior to 2015, resulted in a total of 115 unique published references relevant to this review.

Of these 115 literature references, only 18 were further reviewed in greater detail because they specifically included information on total MTP implant arthroplasty performed for the indications listed in Section 3.

The detailed findings of this literature survey are provided as Appendix A. Based on this systematic literature review, effectiveness for relief of pain or restoration of motion had mixed results. The Gibson et al study (Gibson, 2005) is the only randomized controlled trial we are aware of comparing first total MTP joint implants to the standard of care, arthrodesis. This study established that arthrodesis of the first MTP joint was more effective at reducing pain and produced better functional results than achieved after arthroplasty. Some reports showed higher adverse event rates, mixed results, and notable revision rates (Merkle, 1989, Papagelopoulos, 1994, Gibson, 2005, Titchener, 2015, Lam, 2017) when using devices subject to this classification due to pain and loosening. Part of the challenge with arthroplasty is difficulty in mimicking the native joint and the various anatomical and mechanical stresses it endures. According to literature, revisions of total MTP joint arthroplasty are challenging to manage as significant bone loss is introduced by the initial procedure (Lam, 2017) and places patients at risk for multiple secondary surgeries.

Given the apparently equivocal and low-quality data available in published literature, the Panel will be asked to comment on how available evidence is used to determine the choice to use these devices in cemented total first MTP joint implant arthroplasty. As part of this discussion, the Panel will be asked to explore the outcomes that provide clinically meaningful benefit and what types of evidence (such as clinical evidence) would be helpful to support mitigation of the identified risks.

6. Risks to Health Identified through Medical Device Reports (MDRs)

6.1 Overview of the MDR System

The MDR system provides FDA with information on medical device performance from patients, health care professionals, consumers and mandatory reporters (manufacturers, importers and device user facilities). The FDA receives MDRs of suspected device-associated deaths, serious injuries, and certain malfunctions. The FDA uses MDRs to monitor device performance, detect potential device-related safety issues, and contribute to benefit-risk assessments of these products. MDRs can be used effectively to:

- Establish a qualitative snapshot of adverse events for a specific device or device type
- Detect actual or potential device problems used in a “real world” setting/environment

Although MDRs are a valuable source of information, this passive surveillance system has limitations, including the submission of incomplete, inaccurate, untimely, unverified, duplicated or biased data. In addition, the incidence or prevalence of an event cannot be determined from this reporting system alone due to potential under-reporting of events and lack of information about the frequency of device use. Finally, the existence of an adverse event report does not definitely establish a causal link between the device and the reported event. Because of these limitations, MDRs comprise only one of the FDA’s tools for assessing device performance. As such, MDR numbers and data should be taken in the context of the other available scientific information.

6.2 MDR Data: Cemented Total First MTP Joint Implants

Individual MDRs for metal/polymer semi-constrained toe (metatarsophalangeal joint) prostheses are reported through FDA’s Manufacturer and User Facility Device Experience (MAUDE) Database, which houses mandatory reports from medical device manufacturers, importers and user facilities, as well as voluntary reports from entities such as health care professionals, patients and consumers.

Two different searches were performed to identify all MDRs related to devices under the LZJ product code: one search was conducted using product code LZJ and one search was conducted using brand names that include ‘toe’. The results of these queries were combined, and duplicate results were identified and removed. Reports for different devices were removed using the following fields: manufacturer names, brand name, catalog number, model number, premarket submission number, and narratives. Multiple events for the same patient event were removed during the individual review. MDRs referencing uncemented use and literature articles were also removed. The resulting 40 MDRs are the focus of this review. The reports were received between April 1994 and September 2019 and the adverse events described are listed below. The types of events seen are not unexpected for this device type. Secondary to removal/revision, the most frequently reported patient events were pain

and swelling. The most common device issues included loosening, loss of range of motion, and device failure.

It should be noted that, the method of fixation could not be confirmed in the remaining reports. However, this information is still included in the summary to give an understanding of the reported experience with the currently-marketed devices. In addition, the following limitations for MDRs should be taken into consideration when evaluating the data below:

- Potential submission of incomplete, inaccurate, untimely, unverified, or biased data
- Incidence or prevalence of an event cannot be determined from this reporting system alone
- Confirming whether a device actually caused a specific event can be difficult based solely on information provided in a given report.
- MAUDE data does not represent all known safety information for a reported medical device.

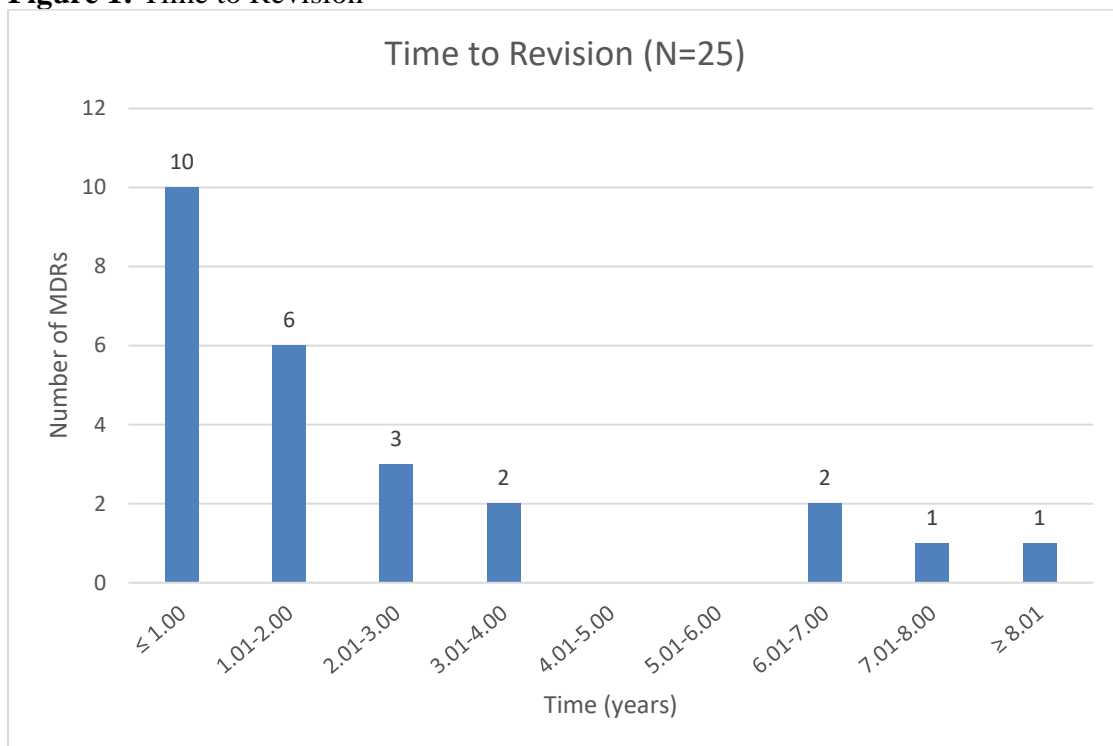
Table 2: Adverse Events (Reports Received between April 1994 and September 2019)

Adverse Event	Count
Removal/Revision (includes 1 revision expected, 1 revision planned, 2 revision recommended)	31
Pain	21
Loose (includes 2 lucencies)	12
Limited/Loss of range of motion (includes 1 no range of motion)	7
Swelling	5
Bone erosion/loss	4
Device failure (2 poly separated from implant, 1 fracture of device, 1 cobalt chrome peeled off head of implant)	4
Reaction (1 multiple chemical sensitivity, 1 allergic reaction probable, 2 metallosis)	4
Migration	3
Discoloration (1 discoloration around implant, 1 black substance)	2
Erythema	2
Infection (includes 1 osteomyelitis)	2
Misplacement (1 improper surgical positioning based on localized burnishing of head component and damage on rim of titanium stem, 1 possible misplacement or trauma)	2
Trauma	2
Ambulation difficulties	1
Cyst	1
Discomfort	1
Dislocation	1
Edema	1
Fatigue	1
Fracture of phalanx	1
Headache	1
Instability	1
Malaise	1
Migration	1
Patient nonconformance	1
Stiffness	1
Subsidence	1
Tissue damage	1
User error (surgeon did not follow surgical technique - cuts were not co-planar)	1
Wear	1

Note: The total number of adverse events may not equal the total number of reports; each report may be associated with multiple events.

Time to revision was analyzed as cemented total first MTP joint implants are considered permanent implants. Time to revision was calculated by subtracting the date of implantation from the date of device explantation. This information was correctly provided in 22 MDRs. Three additional reports contained the time to revision in their narrative fields; these are also included. (Note: if only a year is included, the date was estimated as January 1st of that year). Although time to revision was reported, there are limitations to the reports regarding activity levels or sufficient details related to cause for all reported revisions.

Figure 1: Time to Revision



7. Recall History

7.1 Overview of Recall Database

The Medical Device Recall database contains Medical Device Recalls classified since November 2002. Since January 2017, it may also include correction or removal actions initiated by a firm prior to review by the FDA. The status is updated if the FDA identifies a violation and classifies the action as a recall and again when the recall is terminated. FDA recall classification may occur after the firm recalling the medical device product conducts and communicates with its customers about the recall. Therefore, the recall information posting date ("create date") identified on the database indicates the date FDA classified the recall, it does not necessarily mean that the recall is new.

7.2 Recall Results: Cemented Total First MTP Joint Implants

A review of the recall database using the product code LZJ returned one Class II recall. The recall was associated with instruments associated with the Arthrosurface device and not the device itself. The products were recalled due to an issue with sterilization.

8. Summary

Since the initial clearance, there have been twelve (12) subsequent clearances for cemented total first MTP joint implant devices via the 510(k) process with cement as the method of fixation. These submissions required a demonstration of substantial equivalence and did not include clinical data.

The clinical data available in the literature reports a mix of cemented and uncemented total first MTP joint implant device use. Of note, only four of the studies solely utilized one fixation method. Merkle et al. (Merkle, 1989) and Papagelopoulos et al. (Papagelopoulos, 1994) utilized cement for all arthroplasty patients. Sinha et al (2010) and Titchener (2015) utilized no cement for all patients. Effectiveness for relief of pain or restoration of motion had mixed results as reported in patient reported outcomes measures and radiographic evaluation. The Gibson et al study (Gibson, 2005) is the only randomized controlled trial we are aware of comparing first total MTP joint implants to the standard of care, arthrodesis. This study established that arthrodesis of the first MTP joint was more effective at reducing pain and produced better functional results than achieved after arthroplasty. In addition, due to reports of higher adverse event rates, mixed results, and poor implant survival as the result of pain and device loosening, surgeons have become cautious regarding use of total first MTP joint implant arthroplasty (Lam, 2017).

The Agency has identified the risk of multiple secondary surgeries as sequelae of device removal. The salvage procedure is arthrodesis once the implant is removed. According to literature, revisions of total MTP joint arthroplasty are challenging to manage as significant bone loss is introduced by the initial procedure (Lam, 2017) and places patients at risk for multiple secondary surgeries.

A search of the MDR database resulted in 40 MDRs for review. The reports were received between April 1994 and September 2019. The types of events seen are not unexpected for this device type and accurately reflect the adverse events noted in the reviewed literature. Secondary to removal/revision, the most frequently reported patient events were pain and swelling. The most common device issues included loosening, loss of range of motion, and device failure. Of the twenty-five reports that had available data on time to revision, sixteen (64%) reported revision in the first two years after implantation.

In Table 3, FDA has identified the following risks to health for cemented total first MTP joint replacement devices based upon literature findings, the Manufacturer and User facility Device Experience (MAUDE) database, and the risks associated with total joint arthroplasty devices; however, this list may not be exhaustive:

Table 3: Potential Risks to Health Associated with Cemented Total First MTP Joint Implants

Identified Potential Risk	Description/Example
1. Failure at the bone/implant interface (e.g., lack of hallux purchase; implant migration; loosening of the prosthesis)	Components may loosen, migrate, or disengage from the bone; this may result in pain, injury, or loss of correction.
2. Fracturing of the metatarsal head or base of the proximal phalanx during implantation	During the surgical procedure there is a risk of fracturing of the metatarsal head or base of the proximal phalanx when implanting the device which may cause prolonged surgery times, pain, and loss of correction.
3. Osteolysis or heterotopic ossification around the implant system	There is a risk of osteolysis or heterotopic ossification around the implant system which may lead to pain, implant failure, loss of function, or loss of correction.
4. Sesamoid pathology	There is a risk of sesamoid pathology (e.g., subluxation, arthrosis of the metatarso-sesamoid junction) associated with total MTP joint replacement which may cause pain and loss of function.
5. Recurrence of the hallux deformity	There is a risk that the hallux deformity may recur due to user error, disease state, or patient non-compliance. This may result in pain, loss of function, or additional procedures.
6. Painful/limited first MTP joint range of motion	There is a risk of pain and stiffness associated with MTP joint replacement which may limit the range of motion.
7. Implant breakage or disassociation of components	Components may fracture, wear, or disassemble, resulting in mechanical or functional failure; this may result in pain, injury, or loss of correction
8. Infection	There is a risk of infection in the wound or around the implant. This may cause pain, stiffness, swelling, fever, or fatigue.
9. Dislocation/Subluxation	Components may partially or fully dislocate leading to pain, loss of function, or loss of correction.
10. Use Error	Risks of use error may include difficulty or inability to implant the device components or incorrect placement of the device. This may lead to mechanical or functional failure and result in pain or injury.
11. Adverse Tissue Reaction	Device material(s) may elicit adverse tissue reactions, such as foreign body response, metal allergy, and metal toxicity

Identified Potential Risk	Description/Example
12. MR induced migration and heating and image artifact	Some of the materials used to manufacture cemented total first MTP joint replacements may create a risk of migration and heating in the MR environment which may lead to pain, injury, and loss of function. There is also a risk of image distortion which may affect the ability to image the surrounding area for new pathologies.
13. Multiple secondary surgeries as sequelae of device removal	There is risk of multiple secondary surgeries as revision of arthroplasty is challenging to manage as significant bone loss is introduced by the initial procedure.

The Panel will be asked to comment on whether this is an accurate list of all of the risks in the overall risk assessment of cemented total first MTP joint implants under product code “LZJ.” In addition, the Panel will be asked to comment on whether any additional risks should be included in the overall risk assessment of these cemented total first MTP Joint Implants.

The risk/mitigation table (Table 4) outlines the identified risks to health and potential controls that FDA could apply to mitigate each identified risk.

Table 4: Summary of Risks to Health and Potential Mitigation Measures for Prosthesis, Toe (Metatarsophalangeal), Joint, Metal/Polymer, Semi-Constrained

Identified Risk	Potential Mitigation Measure
Failure at the bone/implant interface (e.g., lack of hallux purchase; implant migration; loosening of the prosthesis)	Design Characteristics Clinical Information* Labeling Non-clinical Performance Testing
Fracturing of the metatarsal head or base of the proximal phalanx during implantation	Design Characteristics Non-clinical Performance Testing Labeling
Osteolysis or heterotopic ossification around the implant system	Labeling Non-clinical Performance Testing
Sesamoid pathology	Labeling
Recurrence of the hallux deformity	Labeling
Painful/limited first MTP joint range of motion	Design Characteristics Labeling Non-clinical Performance Testing
Implant breakage or disassociation of components	Design Characteristics Non-clinical Performance Testing Labeling
Infection	Cleaning and Sterilization Validation
Dislocation/Subluxation	Design Characteristics Non-clinical Performance Testing
User Error	Labeling Non-clinical Performance Testing

Identified Risk	Potential Mitigation Measure
Adverse Tissue Reaction	Design Characteristics Biocompatibility Testing
MR induced migration and heating and image artifact	Labeling Non-clinical performance testing
Multiple secondary surgeries as sequelae of device removal	Labeling Clinical Information*

* Clinical information may come from a variety of sources, premarket or post-market, including but not limited to, prospective or retrospective studies, literature, and real-world evidence sources (e.g., registries or electronic health records).

The Panel will be asked to discuss each of these potential controls and whether it, either alone or in combination with others, adequately mitigates the identified risk(s).

In addition, the risks associated with multiple secondary surgeries are particularly significant and possibly long-lasting. The Panel will be asked to discuss how the risk of multiple secondary surgeries should influence the selection of cemented total first MTP joint implant arthroplasty when considering the overall benefit and risk profile of the subject devices. The Panel will be asked to comment on the recommended mitigations to address this risk.

Considering the information available, the Panel will be asked to comment on whether cemented total first MTP joint implants under product code “LZJ:”

meet the statutory definition of a Class III device:

- insufficient information exists to determine that general and special controls are sufficient to provide reasonable assurance of its safety and effectiveness, and
- the device is life-supporting or life-sustaining, or for a use which is of substantial importance in preventing impairment of human health, or if the device presents a potential unreasonable risk of illness or injury

or would be more appropriately regulated as Class II, in which:

- general and special controls, which may include performance standards, postmarket surveillance, patient registries and/or development of guidelines, are sufficient to provide a reasonable assurance of safety and effectiveness.

or as Class I, in which:

- the device is subject only to general controls, which include registration and listing, good manufacturing practices (GMPs), prohibition against adulteration and misbranding, and labeling devices according to FDA regulations.

For the purposes of classification, FDA considers the following items, among other relevant factors, as outlined in 21 CFR 860.7(b):

1. The persons for whose use the device is represented or intended;

2. The conditions of use for the device, including conditions of use prescribed, recommended, or suggested in the labeling or advertising of the device, and other intended conditions of use;
3. The probable benefit to health from the use of the device weighed against any probable injury or illness from such use; and
4. The reliability of the device.

FDA believes general controls by themselves are insufficient to provide reasonable assurance of the safety and effectiveness and sufficient information exists to establish special controls to adequately mitigate the risks to health and provide reasonable assurance of device safety and effectiveness for this device type. As such, FDA believes that Class II is the appropriate classification for cemented total first MTP joint implants.

The Panel will be asked to discuss whether there is agreement with FDA's proposed classification of Class II with special controls for cemented total first MTP joint implants. If there is not agreement with FDA's proposed classification, the Panel will be asked to provide a rationale for recommending a different classification.

9. References

- Ess P, Hämäläinen M, Leppilähti J. Non-constrained titanium-polyethylene total endoprosthesis in the treatment of hallux rigidus. A prospective clinical 2-year follow-up study. *Scand J Surg* 91(2):202–207, 2002.
- Fuhrmann RA, Wagner A, Anders JO. First metatarsophalangeal joint replacement: the method of choice for end-stage hallux rigidus? *Foot Ankle Clin* 8(4):711–721,vi, 2003.
- Gerbert J, Chang TJ. Clinical experience with two-component first metatarsal phalangeal joint implants. *Clin Podiatr Med Surg*. 1995 Jul;12(3):403-13.
- Gibson JN, Thompson CE. Arthrodesis or total replacement arthroplasty for hallux rigidus: a randomized control trial. *Foot Ankle Int* 2005;26(9):680–90.
- Gross CE, Hsu AR, Lin J, Holmes GB, Lee S. Revision MTP arthrodesis for failed MTP arthroplasty. *Foot Ankle Spec*. 2013 Dec;6(6):471-8. doi: 10.1177/1938640013502725. Epub 2013 Sep 11
- Johnson KA, Buck PG. Total replacement arthroplasty of the first metatarsophalangeal joint. *Foot Ankle*. 1981 May;1(6):307-14. doi: 10.1177/107110078100100602.
- Khoury WE, Fahim R, Sciulli JM, Ehredt DJ Jr. Management of failed and infected first metatarsophalangeal joint implant arthroplasty by reconstruction with an acellular dermal matrix: a case report. *J Foot Ankle Surg*. 2012 Sep-Oct;51(5):669-74.
- Lam A, Chan JJ, Surace MF, Vulcano E. Hallux rigidus: How do I approach it? *World J Orthop*. 2017;8(5):364–371. Published 2017 May 18. doi:10.5312/wjo.v8.i5.364
- Malhotra K. et. al. Interposition bone block arthrodesis for revision hallux metatarsophalangeal joint surgery: a case series. *Foot Ankle Int*. 2015 May;36(5):556-64. doi: 10.1177/1071100714563536. Epub 2014 Dec 10.
- Marx, R et al. Updating the Assignment of Levels of Evidence. *The Journal of Bone and Joint Surgery*. 2015 Jan 7; 97 (1) p1-2.
- Merkle P, Sculco TP. Prosthetic replacement of the first metatarsophalangeal joint. *Foot Ankle*. 1989 Jun;9(6):267-71.
- Myerson MS, Schon LC, McGuigan FX, Ozgur A. Result of arthrodesis of the hallux metatarsophalangeal joint using bone graft for restoration of length. *Foot Ankle Int*. 2000;21(4):297-306.
- Papagelopoulos PJ, Kitaoka HB, Ilstrup DM. Survivorship analysis of implant arthroplasty for the first metatarsophalangeal joint. *Clin Orthop Relat Res* 1994; 302:164–72.

Pulavarti RS, McVie JL, Tulloch CJ. First metatarsophalangeal joint replacement using the bio-action great toe implant: intermediate results. *Foot Ankle Int* 26 (12):1033–1037, 2005.

Sinha S, McNamara P, Bhatia M, Louette L, Stephens I. Survivorship of the bio-action metatarsophalangeal joint arthroplasty for hallux rigidus: 5-year follow-up. *Foot Ankle Surg.* 2010 Mar;16(1):25-7.

Stevens J, deBot R, Hermus JPS, van Rhijn LW, Witlox AM. Clinical outcomes following total joint replacement and arthrodesis for hallux rigidus. A systematic review. *Journal of Bone and Joint Surgery Reviews* 2017;5(11)e2. <http://dx.doi.org/10.2106/JBJS.RVW.17.00032>.

Titchener AG, Duncan NS, Rajan RA. Outcome following first metatarsophalangeal joint replacement using TOEFIT-PLUS™: A mid-term alert. *Foot Ankle Surg.* 2015 Jun;21(2):119-24.

Zammit GV, Menz, HB, Munteanu SE, Landorf KB, Gilheany MF. Interventions for treating osteoarthritis of the big toe joint. *Cochrane Database Syst Rev.* 2010 Sep 8;(9):CD007809 <http://www.ncbi.nlm.nih.gov/pubmedhealth/PMH0014626/>

Appendix A Systematic Literature Review on Cemented Total First MTP Joint Implants

It is important to recognize that the literature related to the use of cemented total MTP joint implants is limited due to the size of the studies and the study designs, and therefore it is difficult to draw definitive conclusions on the performance of this device type. Of the articles that were reviewed in detail, only eight of the sixteen included summary clinical data on the primary use of total first MTP joint implants. A summary of those studies is included in **Table 5** below. Notably, only two studies used cement as the method of fixation for every patient (Merkle, 1989, Papagelopoulos, 1994). The remaining studies used no cement in some or all of the patients and did not stratify their results according to the method of fixation. However, these studies were included for reference since they studied an FDA-cleared device or a device similar to those currently cleared in the U.S.

Of the remaining eight articles, four provided clinical experience on revision operations and post-operative complications. The remaining articles include background information and general overviews of overall performance for this device type.

Table 5: Literature Summary

Citation	Device Types	Study Type / Level of Evidence ^b	Indications	Fixation Method	Mean Follow-Up (Range)	Results/Conclusions
Merkle (1989)	Semiconstrained Ti alloy and HDP ^c device	Case Series Level IV	Primary osteoarthritis, hallux rigidus, rheumatoid arthritis.	Cement	21 months	<p><u>Study details:</u> Follow-up for 9 patients; 11 devices</p> <p><u>Adverse events:</u></p> <ul style="list-style-type: none"> ▪ Device loosening: 54% ▪ Device removals: 2 ▪ Deep infection: 1 <p><u>Outcomes (subjective):</u> Excellent/good: 4 patients Fair/poor: 5 patients</p> <p><u>Conclusions:</u> Recommendation that research should be directed toward better fixation methods as results were unsatisfactory compared to other standard operations. One of the standard operations (i.e., cheilectomy, arthrodesis, Silastic, or resection arthroplasty) should be used in treatment of hallux rigidus.</p>
Papagelopoulos, (1994)	<p>Cemented SS/PE^c Johnson device (DePuy)</p> <p>Cemented SS/PE device (Richards) Cemented SS/PE (Richards)</p> <p>Silicone devices</p>	Case Series Level IV	Hallux rigidus; hallux valgus, rheumatoid arthritis	Mix of cemented and uncemented devices	12 yrs. (2-17 yrs)	<p><u>Study details:</u> Reported results of four different implants: two different uncemented silicone implants (n=63), cemented SS/PE Johnson device (DePuy, n=27) and cemented SS/PE Richards device (n=3). Outcomes were not stratified by fixation method and results included both cemented (n=30) and uncemented (n=63) devices.</p> <p><u>Adverse Events:</u> For cemented devices:</p> <ul style="list-style-type: none"> ▪ Device loosening: Definite: 56%; Probable: 9%; Possible: 22%; None: 13% ▪ Device migration: Definite: 26% (phalangeal component); Definite: 26% (metatarsal component)

Citation	Device Types	Study Type / Level of Evidence ^b	Indications	Fixation Method	Mean Follow-Up (Range)	Results/Conclusions
						<p><u>Outcomes:</u> For cemented devices:</p> <ul style="list-style-type: none"> ▪ Pain: Severe: 0%; Moderate: 17%; Mild 33%; None: 50% ▪ Patient response: Much improved: 46%; Improved: 29%; Same:21%; Worse: 4% <p>For all device types: Implant survival was 90% at 5 years, 86% at 10 years and 82% after 15 years</p> <p><u>Conclusions:</u> Survivorship analysis and clinical results were satisfactory in many patients. However, radiographic results showed signs of impending problems, but radiographic results did not correlate with clinical pain or dysfunction in patients who did not undergo reoperation.</p>
Ess (2002)	ReFlexion MTP Endo-prosthesis	Case Series Level IV	Hallux rigidus	Uncemented except for one distal component which was cemented	24 months	<p><u>Study details:</u> 10 devices implanted in 10 patients</p> <p><u>Adverse events:</u></p> <ul style="list-style-type: none"> ▪ Prosthesis subluxation: n=1 ▪ Recurrence of severe valgus alignment: n=1 ▪ Superficial wound infection: n=1 ▪ Radiological loosening: n=1 <p><u>Outcomes:</u></p> <ul style="list-style-type: none"> ▪ AOFAS scores: excellent, 5; good, 1; fair, 2; poor, 2 ▪ Satisfaction: satisfied, 8; dissatisfied, 2 ▪ VAS (mean): Pre-op, 7.6 (SD 2.0); Post-op, 1.1 (SD, 1.4)

Citation	Device Types	Study Type / Level of Evidence ^b	Indications	Fixation Method	Mean Follow-Up (Range)	Results/Conclusions
						<ul style="list-style-type: none"> ▪ 1st MTP joint pain outcomes: Painless, 5; Mild, occasional pain, 4; Moderate, daily pain, 1 ▪ Range of motion outcomes: Mean extension increased by 25 degrees (range, 13–38); mean flexion increased by 15 degrees (range, 2–35) <p><u>Conclusions:</u> This non-constrained titanium-polyethylene total arthroplasty gave satisfactory 2-year outcome in 60 % of the patients. It is an alternative treatment for hallux rigidus in low demand patients. It is not recommended for athletes and young people, because high forces acting on the prosthesis may cause a failure.</p>
Fuhrman (2003)	ReFlexion MTP Endoprosthesis	Case Series Level IV	Hallux rigidus, revision surgery following prior treatment with resection arthroplasties, cheilectomies, or silicone implants	Mix of cemented and uncemented devices	39 months	<p><u>Study details:</u> Prospective evaluation of 43 devices implanted in 41 patients; Cement fixation was used in 15 patients for only for phalangeal components, both phalangeal and metatarsal components were cemented in 5 patients</p> <p><u>Adverse events:</u></p> <ul style="list-style-type: none"> ▪ Revision Rate = 9 %; 4 patients revised due to pain and limited dorsiflexion ▪ Lack of appropriate radiographic component alignment noted in 60.5% of prostheses and included valgus deformities (30%), varus deformities (9%) and planter subluxations (21%) ▪ Radiolucent lines were noted in 23% of all phalangeal components and 9% of all metatarsal components. Radiolucent lines noted along the phalangeal components in 10 feet, 7 with cemented fixation and 3 with uncemented fixation. Signs of implant loosening around the metatarsal

Citation	Device Types	Study Type / Level of Evidence ^b	Indications	Fixation Method	Mean Follow-Up (Range)	Results/Conclusions
						<p>components noted in 4 implants, with an equal distribution for cemented (2) and uncemented (2) fixation</p> <p><u>Outcomes:</u></p> <ul style="list-style-type: none"> ▪ Pain improvement (VAS): preop, 32.8 points, postop, 11.2 points ▪ Improvements noted in patient activity, foot wear and MTP joint motion ▪ Range of passive dorsiflexion increased from 25 degrees (range, 0-35) to 45 degrees (range, 15- 55) <p><u>Conclusions:</u></p> <p>Irrespective of clinical and radiologic results, most of the patients were extremely satisfied with the operation because pain decreased significantly. Although functional assessment after a 3-year follow-up period showed significant improvements with regards to activity, footwear, and MTP joint motion, the overall results were disappointing. The average increase in passive dorsiflexion did not exceed 20 degrees. Moreover, the range of motion seemed to be enhanced at the cost of decreased MTP joint stability. Compared with preoperative findings, the stability worsened significantly. Depending on the patient's satisfaction with the operation, the functional progress, and the marked improvement of plantar pressure characteristics, it was noted that total replacement of the first MTP joint is a challenging and promising field of forefoot surgery. Recommendation was made to direct research toward development of prostheses which allow for increased dorsiflexion and adequate primary stability.</p>

Citation	Device Types	Study Type / Level of Evidence ^b	Indications	Fixation Method	Mean Follow-Up (Range)	Results/Conclusions
Gibson (2005)	Biomet toe replacement	Randomized Controlled Trial Level I	Hallux rigidus, MTP joint arthritis	Mix of cemented and uncemented devices	24 months	<p><u>Study details:</u> 63 patients were randomized between arthroplasty (27 patients, 39 toes) and arthrodesis (22 patients, 38 toes) performed by single surgeon</p> <p><u>Adverse events:</u></p> <p><u>Arthroplasty Cohort</u></p> <ul style="list-style-type: none"> Revision: 15.4 % (6/39) implants required removal due to phalangeal loosening of uncemented components. This led to protocol deviation to allow cement fixation in the final 9 patients, none of whom experienced device loosening through final follow-up. <p><u>Arthrodesis Cohort</u></p> <ul style="list-style-type: none"> Wound infection: 31.8 % (7/22) of patients <p><u>Outcomes:</u></p> <ul style="list-style-type: none"> Both arthroplasty and arthrodesis provided the benefit of pain reduction to most patients, but the degree of improvement after arthrodesis (82%) exceeded improvement after arthroplasty (45%) Better functional results were observed after arthrodesis compared with arthroplasty. All arthrodesis patients achieved successful fusion <p><u>Conclusions:</u> This study established that arthrodesis of the first MTP joint was more effective at reducing pain and produced better functional results than achieved after arthroplasty.</p> <p>All 38 arthrodeses united at a mean dorsiflexion angle of 26 degrees, with few complications. In the</p>

Citation	Device Types	Study Type / Level of Evidence ^b	Indications	Fixation Method	Mean Follow-Up (Range)	Results/Conclusions
						arthroplasty group, six of the 39 (15.4%) inserted implants required removal because of phalangeal component loosening by 24 months. In the remaining implants, range of motion gained was poor, and these patients tended to bear weight on the outer border of their foot.
Pulavarti (2005)	Bio-Action toe prosthesis	Case Series Level IV	Hallux rigidus, hallux valgus with degenerative changes, failed hallux surgery with degenerative changes, gouty arthritis, rheumatoid arthritis	Uncemented except for one device	47 months (36-69)	<p><u>Study details:</u> Prospective analysis included 32 patients (36 implants). One patient required cement fixation on metatarsal side due to a cyst in the metatarsal head.</p> <p><u>Adverse events:</u></p> <ul style="list-style-type: none"> ▪ Revision Rate =5.5% <p>Two patients had revision procedures due to pain (one excision arthroplasty, one arthrodesis)</p> <ul style="list-style-type: none"> ▪ One interoperative metatarsal fracture was treated with cerclage wiring ▪ Radiolucent lines noted in 12 patients but did not compromise functional outcome <p><u>Outcomes:</u></p> <ul style="list-style-type: none"> ▪ Subjective: excellent, 36%; good, 41.6%, fair, 13.9%; poor, 8.3% ▪ AOFAS rating scale: Preop (mean) score = 26 (range, 8-40) Postop (mean) score = 78 (range, 39-95) ▪ MTP joint arc of motion (mean): 44 (range, 10-80) <p><u>Conclusions:</u> Investigators state that “because of the high biomechanical demands placed on the first MTP joint and the complex interactions between the joints of the foot, routine use of joint replacement arthroplasty cannot be recommended until good</p>

Citation	Device Types	Study Type / Level of Evidence ^b	Indications	Fixation Method	Mean Follow-Up (Range)	Results/Conclusions
						results have been achieved consistently over time from large multicenter trials. Careful explanation to the patients of all other options of treatment including arthrodesis and resection arthroplasty is very important”.
Sinha (2010)	Bio-Action Great Toe Implant	Case Series Level IV	Hallux rigidus	Uncemented	61 months (48-65)	<p><u>Study details:</u> Analysis included 14 patients treated with 15 devices.</p> <p><u>Adverse events:</u></p> <ul style="list-style-type: none"> ▪ Revision surgery: 2 cases, both patients treated with implant removal and arthrodesis due to increased pain <p><u>Outcomes:</u></p> <ul style="list-style-type: none"> ▪ AOFAS rating scale: Mean score at 5 year follow-up: 62 (range, 10-82) ▪ Satisfaction rating: Satisfied: 8 pts; Not satisfied: 6 pts ▪ Radiographic loosening: 14 phalangeal components (93.3%) and 13 metatarsal components (86.6%) showed radiographic signs of loosening with component migration and severe bony resorption. Revision surgery was not recommended as most patients were relatively pain free. <p><u>Conclusions:</u> Investigators noted that radiographic findings did not correlate with the subjective results of pain or dysfunction clinically. It was suggested that the implant functions as a spacer, with the operation producing a result similar to that of an excision arthroplasty. The investigators concluded that the superior functional and subjective results of cheilectomy, excision arthroplasty or arthrodesis were more reliable options”.</p>

Citation	Device Types	Study Type / Level of Evidence ^b	Indications	Fixation Method	Mean Follow-Up (Range)	Results/Conclusions
Titchener (2015)	^a Toefit-Plus (Ti, Co-Cr/poly)	Case Series Level IV	Hallux rigidus	Uncemented	33 months (2-72)	<p><u>Study details:</u> Prospective evaluation of the outcomes of 86 toes in 73 patients with mean follow-up of 33 months. Ten patients lost to follow-up.</p> <p><u>Adverse events:</u></p> <ul style="list-style-type: none"> ▪ Intraoperative fractures or impending fractures requiring cerclage wiring: 8 pts. ▪ Revision rate = 24% (18 pts) at a mean follow-up time of 33 months post-surgery. ▪ Indications for revision surgery: loosening (11 pts), fracture (2), infection (1), dislocation (2), malalignment (1), persistent pain (1). <p><u>Outcomes:</u></p> <ul style="list-style-type: none"> ▪ AOFAS Hallux MTP joint scores (mean) <p><u>Non-revised toes</u> Preop: 41 (27-78, range) Post-op: 91 (62-100, range at 2-3 yrs)</p> <p><u>Revised toes</u> Preop: 43 (29-65, range) Post-op: 77 (56-100, range, pre-revision)</p> <ul style="list-style-type: none"> ▪ Radiographic loosening or lucency: 43% (32/75) which occurred most commonly on phalangeal side and was not necessarily symptomatic <p><u>Conclusions:</u> The investigators concluded that first MTP joint replacement was an option in hallux rigidus and patients who were not revised experienced a significant improvement in AOFAS scores at medium term follow-up. However, the revision rate of 24% at a mean of 33 months post-surgery was</p>

Citation	Device Types	Study Type / Level of Evidence ^b	Indications	Fixation Method	Mean Follow-Up (Range)	Results/Conclusions
						unacceptably high and use of this type of prosthesis was discontinued. The investigators advocated for establishment of national registries to assess long term outcomes.

^aToefit-Plus device has not received clearance for use in the United States

^bStudy type and level of evidence based on: Marx, R et al. Updating the Assignment of Levels of Evidence. The Journal of Bone and Joint Surgery. 2015 Jan 7; 97 (1) p1-2.

^cAbbreviations: HDP, high density polyethylene; PE, polyethylene; SS, stainless steel; PE, polyethylene; American Orthopaedic Foot and Ankle Society, AOFAS; VAS, Visual Analog Scale; MTP, metatarsophalangeal; CO, cobalt; Cr, chromium; Ti, titanium; pts, patients; yrs, years.

In addition to the individual studies identified above, a recent systematic review (Stevens, 2017) was performed to assess the outcomes of arthrodesis and total joint replacement, the two most commonly performed operative treatments for hallux rigidus. The outcomes of 33 studies describing a total of 741 arthrodeses and 555 total joint replacement were analyzed. This review concluded that “arthrodesis is superior for improving clinical outcome and reducing pain and is less often accompanied by intervention-related complications and revisions, compared with total joint replacement in patients with symptomatic hallux rigidus.” Future high-quality studies investigating clinical outcomes with use of validated scoring systems was recommended to verify the conclusions of this analysis.

In addition to the primary clinical experience with total first MTP joint arthroplasty outlined in **Table 5**, another issue outlined in the literature is that revisions of arthroplasties can be problematic due to low or poor bone stock and the frequent need for bone grafts. Gross and co-authors in a small series of 11 patients concluded: “that although salvage arthrodeses for failed arthroplasties generally have favorable satisfaction rates and are a powerful tool in treating this painful condition, they are fraught with complications. They unite slower, have a significantly higher reoperation rate, and have lower AOFAS scores than primary fusions.” (Gross, 2013) In this study, the interval time between primary surgery and revision arthrodesis was on average 84.2 months. There was a high reoperation rate (58%), with seven revision procedures occurring in 11 patients who underwent 12 salvage arthrodeses. The average time to radiographic fusion was 6.9 ± 4.8 months; 41.7% of patients had a delayed union (> 6 months to fusion). Two patients had symptomatic nonunions (16.7%). All the patients had an improvement in their AOFAS metatarsophalangeal-interphalangeal (MTP-IP) score.

After implant removal following a failed total first MTP joint arthroplasty, the hallux is left shortened with bone loss. Arthrodesis of the hallux metatarsal phalangeal joint with bone graft is required to restore bone loss and length of the first ray. Arthrodesis after primary surgery failure in the hallux metatarsal phalangeal joint is technically difficult and results in a high rate of nonunion (Myerson, 2000). Myerson et al. (Myerson, 2000) noted that nonunion occurred in 21 % of their patients in a case series of patients who needed arthrodesis after primary surgery failure. Malhotra et al. (Malhotra, 2015) found a nonunion rate of 12% in their case series of using an interposition bone block for revision hallux MTP joint surgery. The rate of nonunion following salvage (revision) arthrodesis performed to treat a failed total MTP joint arthroplasty using this procedure is twice as high as the nonunion rate of an MTP joint fusion performed to treat hallux rigidus as a primary procedure. In a recent systematic review (Stevens, 2017), nonunion or delayed union occurred in 6.6% (49 of 741 cases) when performed as the initial procedure. If inadequate hallux lengthening occurs then the patient is at risk for weightbearing on the lesser toes and metatarsals (transfer metatarsalgia) and subsequently at risk for need for further procedures (e.g. Weil osteotomy) (Myerson, 2000; Johnson, 1981).

Adverse Events Associated with Prosthesis, Toe (Metatarsophalangeal), Joint, Metal/Polymer, Semi-Constrained

Adverse events reported for total metatarsophalangeal joint arthroplasty devices include failure at the bone/implant interface (e.g., lack of hallux purchase; implant migration; loosening of the prosthesis) reduced range of motion, pain, osteolysis or heterotopic ossification around the implant system, fracture, infection, decrease in joint stability, subluxation, sesamoid pathology, recurrence of the hallux deformity, and hallux shortening with revision to fusion or nonunion with revision using a graft (auto- or allograft) (Gerbet, 1995, Khoury, 2012, Merkle, 1989, Papagelopoulos, 1994, Ess, 2002, Fuhrmann, 2003, Gibson, 2005, Pulavarti, 2005, Sinha, 2010, Titchener, 2015). Patients are also at additional risk of transfer metatarsalgia if after implant removal the hallux is shortened by fusion or fusion with allograft and non-union (Johnson, 1981). These adverse events would be considered expected and be evaluated for any future designs.

Effectiveness Associated with Prosthesis, Toe (Metatarsophalangeal), Joint, Metal/Polymer, Semi-Constrained

The potential appeal of joint arthroplasty for hallux rigidus is similar to its benefits in other joints in the body. The ideal implant should relieve pain, restore motion, improve function, and maintain joint stability. However, a number of studies reviewed showed mixed results in maintenance or restoration of motion and pain relief.

The Gibson et al study (Gibson, 2005) is the only randomized controlled trial we are aware of comparing first total MTP joint implants to the standard of care, arthrodesis. This study established that arthrodesis of the first MTP joint was more effective at reducing pain and produced better functional results than achieved after arthroplasty. There was a 15% revision rate in the arthroplasty group and the remaining patients who were not revised had poor range of motion and tended to bear weight on the outer portion of their foot. Of the toes that were not revised at 2 years, the active range of motion was 14 degrees which was not significantly greater than the pre-op range of motion of 11 degrees. In terms of pain measured by the VAS pain score, results between the two groups were not significantly different. Out of the remaining patients who were not revised at 2 years, 40% would not have undergone the same surgery again.

The remaining case series articles cited in the table above also show mixed results as reported in patient outcome measures and radiographs. Finally, our review of the MDR reports (Section 6.2 of this Summary) also showed pain-related events.

Overall Literature Review Conclusions

The review of published literature for total first toe MTP joint arthroplasty included a mix of cemented and uncemented implant devices. Merkle (Merkle, 1989) and Papagelopoulos (Papagelopoulos, 1994) were the only case studies FDA identified that reported on cemented use only. However, the other studies were included for reference

since they either provided some data on cemented use of this device type and/or studied one of the FDA-cleared devices or a device similar to those currently FDA-cleared. Effectiveness for relief of pain or restoration of motion had mixed results. The Gibson et al (Gibson, 2005) study concluded that arthrodesis of the first MTP joint was more effective at reducing pain and produced better functional results than achieved after arthroplasty. Some reports showed high adverse event rates, mixed results, and notable revision rates (Merkle, 1989, Papagelopoulos, 1994, Gibson, 2005, Titchener, 2015, Lam, 2017) due to pain and loosening. Part of the challenge with arthroplasty is difficulty in mimicking the native joint and the various anatomical and mechanical stresses it endures. According to literature, revisions of total MTP joint arthroplasty are challenging to manage as significant bone loss is introduced by the initial procedure (Lam, 2017) and places patients at risk for multiple secondary surgeries.