Regulation of UHMWPE Biomaterials in Total Joint Arthroplasty

Michael Kasser, PhD
Reviewer, Orthopedic Joint Devices Branch
Division of Surgical, Orthopedic, and Restorative Devices
Office of Device Evaluation/CDRH/FDA

Outline

- Regulatory background
- The 510(k) Flowchart
- Simple regulatory examples
- Taking crosslinked UHMWPE through the chart
- Taking Vit. E UHMWPE through the chart

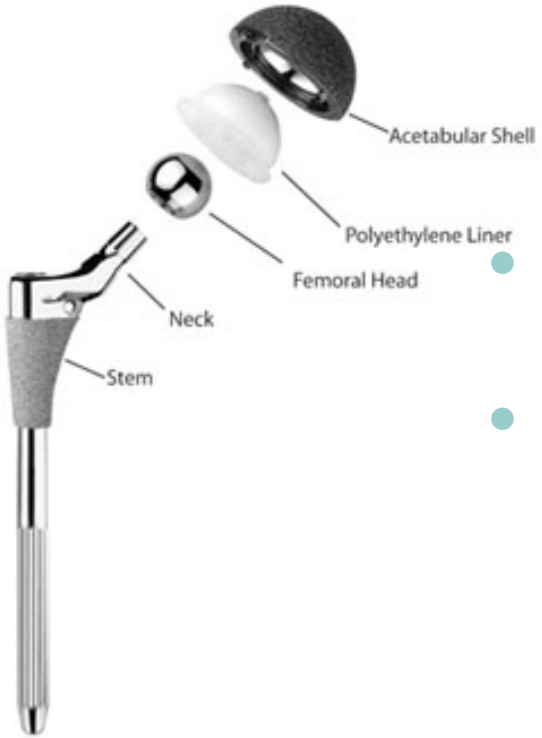
Device Regulation History

- With the amendment of The Food, Drug and Cosmetic Act of 1976 FDA began to regulate medical devices
- All devices on the market prior to May 28, 1976 were sorted into a device regulation and assigned a risk class
- Any new devices that are not substantially equivalent to pre-amendment are placed into the highest risk class

Hip Device Regulations

Hips were sorted into different regulations depending on

- Bearing material
  - metal on poly, ceramic on poly, metal on metal, ceramic on ceramic, metal on articular cartilage, ceramic on articular cartilage
- Degree of constraint
  - semiconstrained, constrained
- Fixation Method
  - cemented or uncemented



Risk Class

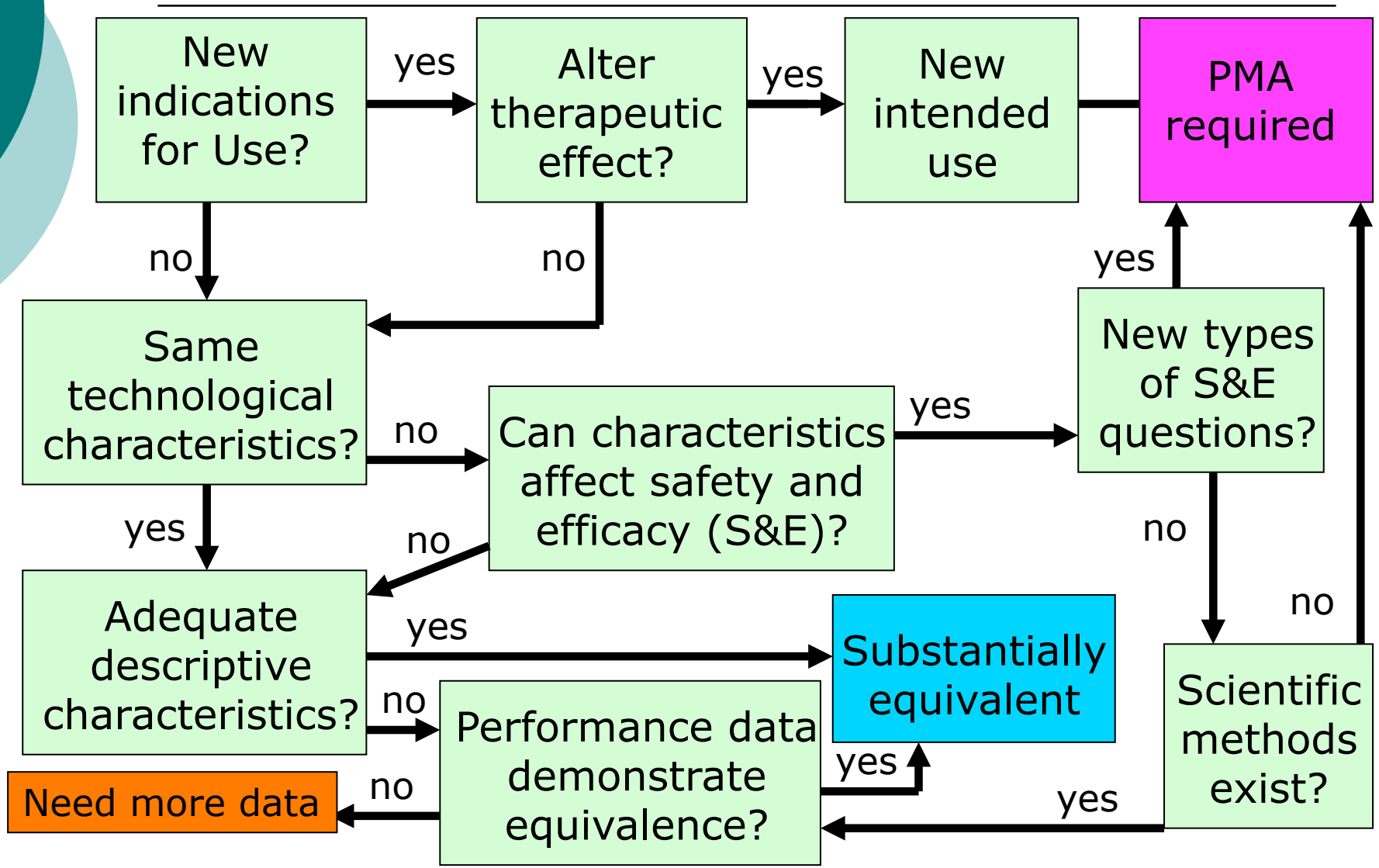
Class	Risk	Device Example	Regulatory Pathway
I	Low	Scalpel	Registration with FDA (GMP)
II	Moder-ate	Metal on poly hip	510(k) (substantial equivalence)
III	High	Ceramic on ceramic hip	Premarket Approval (PMA) or de Novo

510(k) vs. PMA

	Submis-sion Cost	Review Time	Clinical data	GMP	Label-ing
510(k)	$4,348	90/360 days	10%	On file	Draft
PMA	$236,298	180/360 days	100%	Re-viewed	Final

PMAs must stand on their own, while 510(k)s may borrow from other 510(k) devices

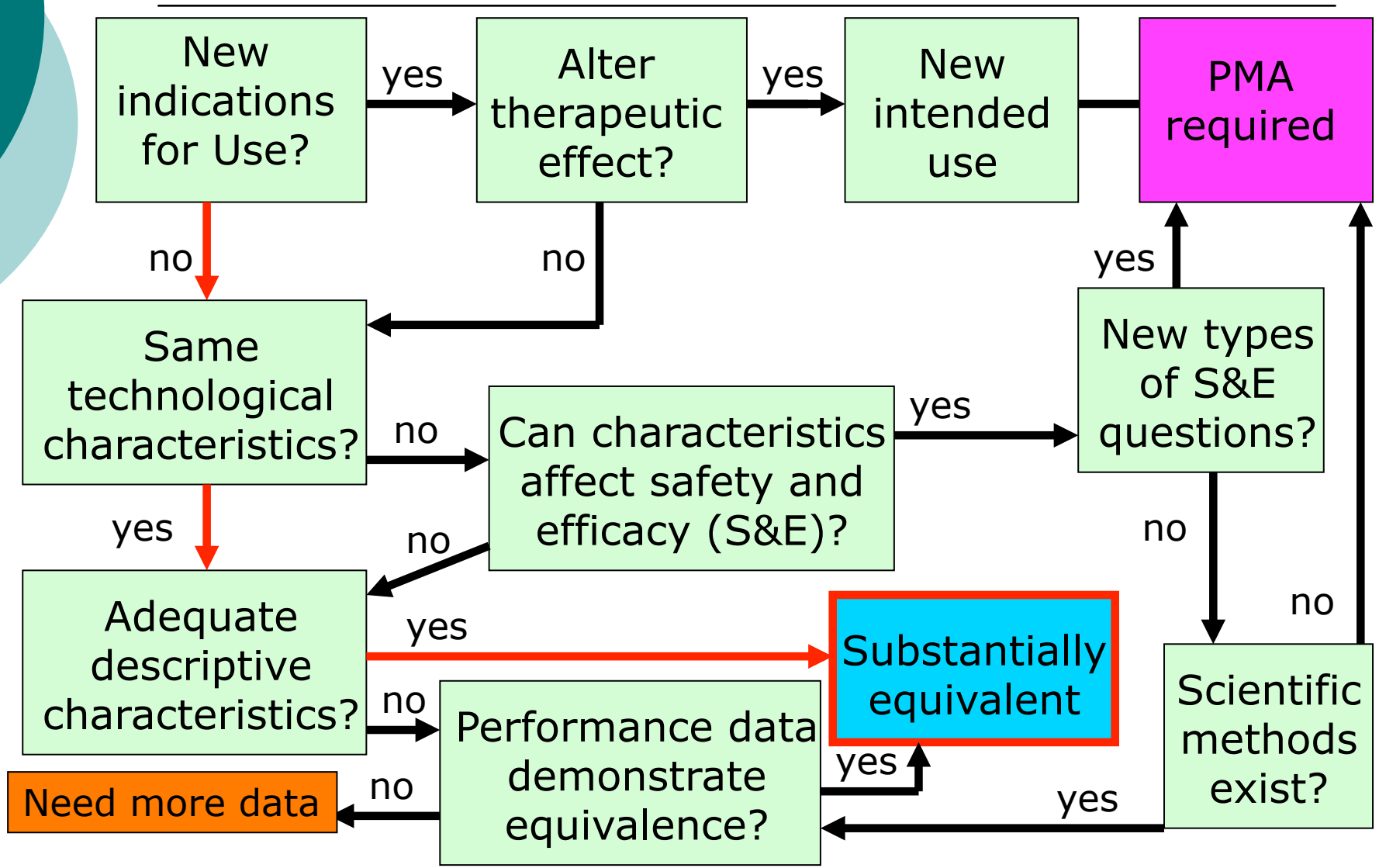
The 510(k) Flowchart (abbreviated)



Simple Screw Example

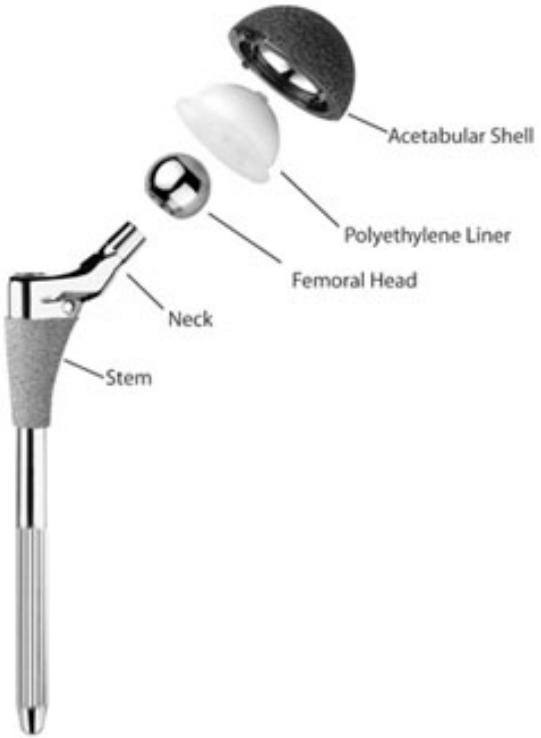
- Device modification: Addition of screw lengths and diameters to screw system
  - New screws have larger diameter
  - New screws have equivalent thread lengths
- Predicate device: Cleared screw System
- Indications: Same as predicate

Simple Screw Example

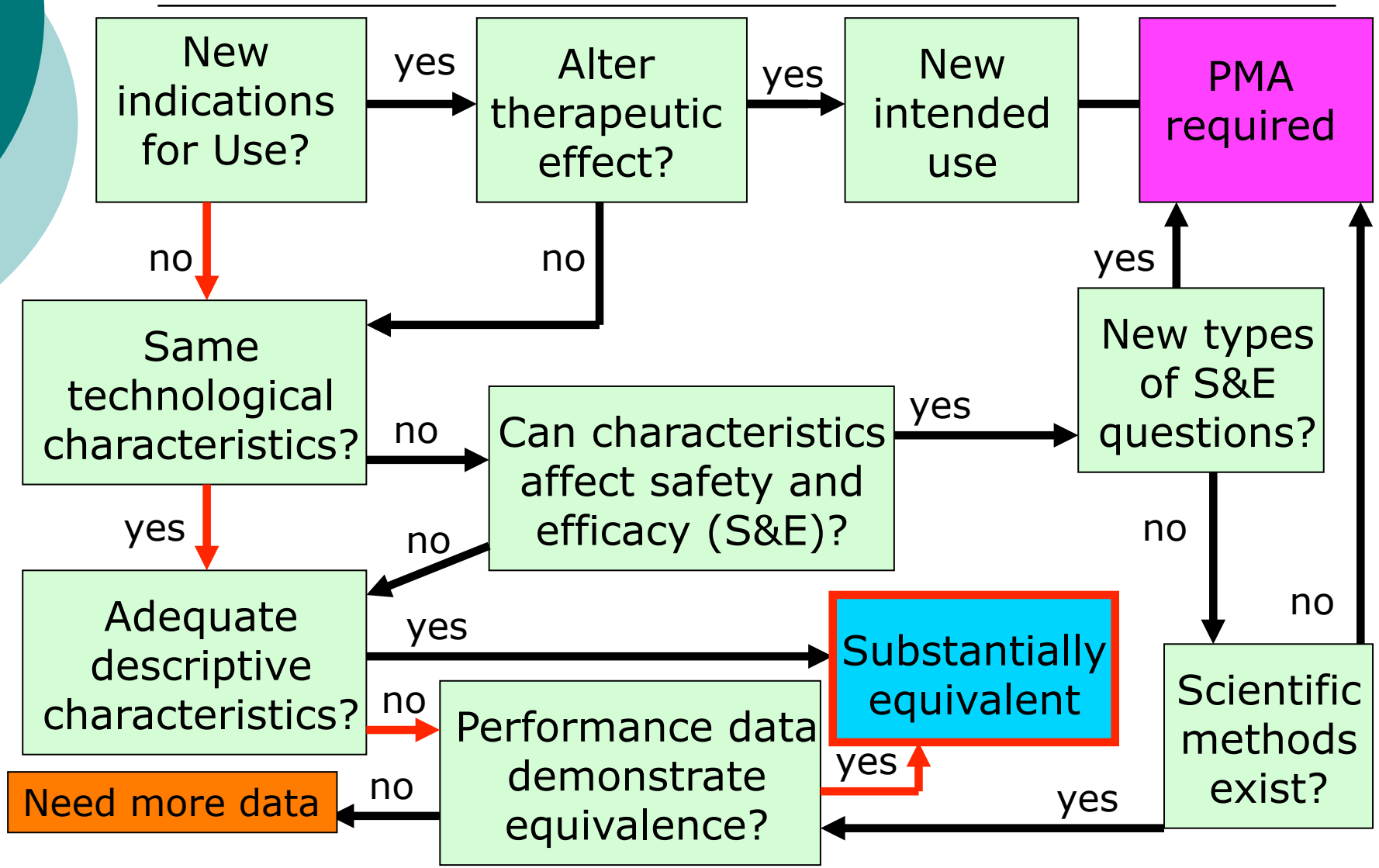


Simple Total Hip Example

- Device modification: Addition of larger femoral heads and acetabular liners to hip system
  - Same articulating material
  - Same offsets
- Predicate device: Cleared hip System
- Indications: Same as predicate



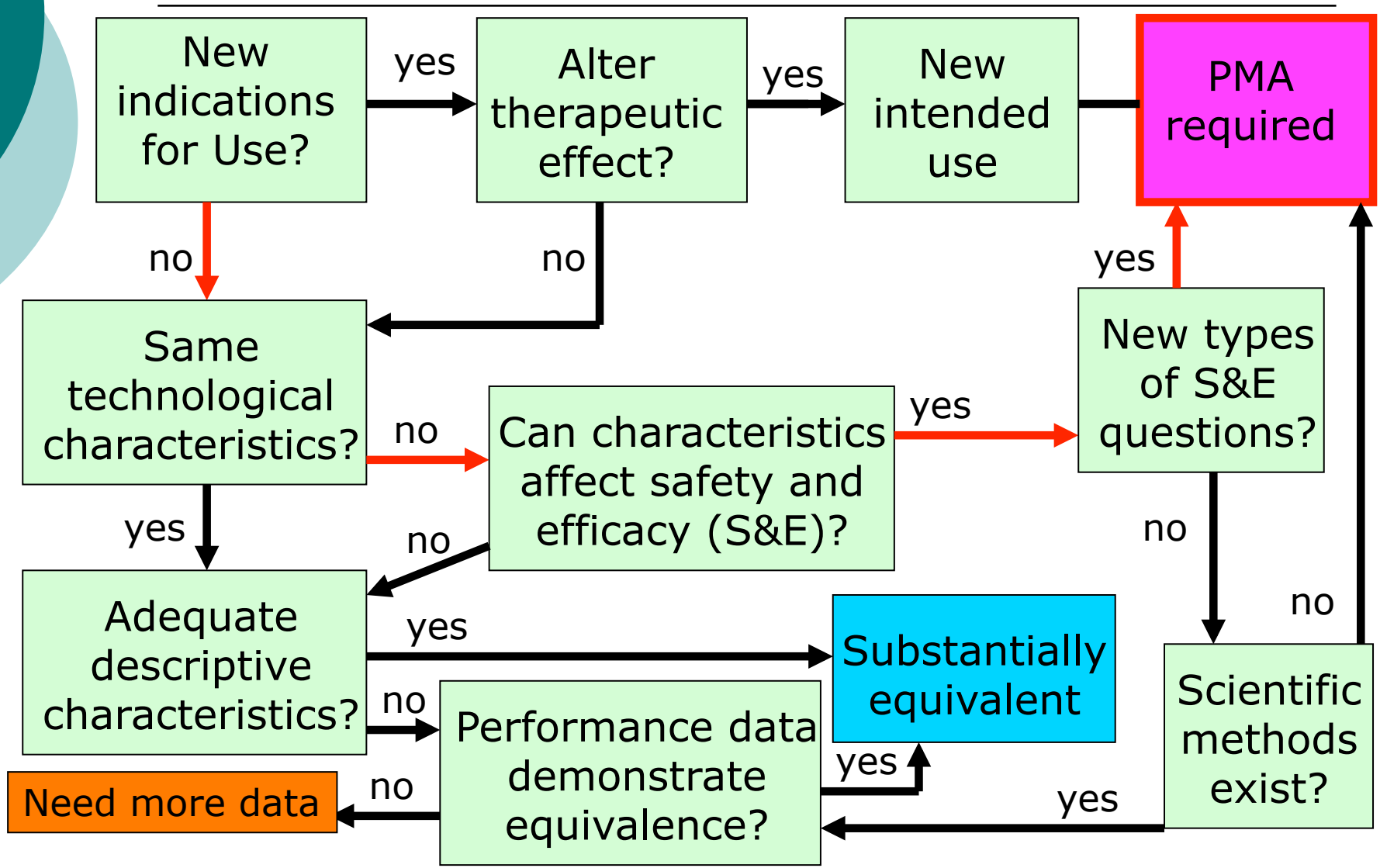
Simple Hip Example



Ceramic on Metal Hip Example

- Device modification: Change of the femoral head from metal to ceramic
  - Different articulating material
  - Geometry is changed
- Predicate device: Cleared MoM hip System
- Indications: Same as predicate

Ceramic on Metal Example



XLPE Example

- Device modification: 100 kGy irradiation followed by melt (150 °C)
  - Same head/liner dimensions
  - Same liner/cup locking mechanism
- Predicate device: Conventional hip system (25 – 40 kGy gamma sterilization and package in inert environment)
- Indications: Same as predicate

XLPE Material Testing

Safety and Efficacy Question	Tensile properties	Oxidation resistance	Fatigue resistance
Scientific Method	Tensile testing, small punch testing	Accelerated aging, OI, free radical content	Fatigue crack propagation testing, Izod impact test

See ASTM F2565

XLPE Material Testing

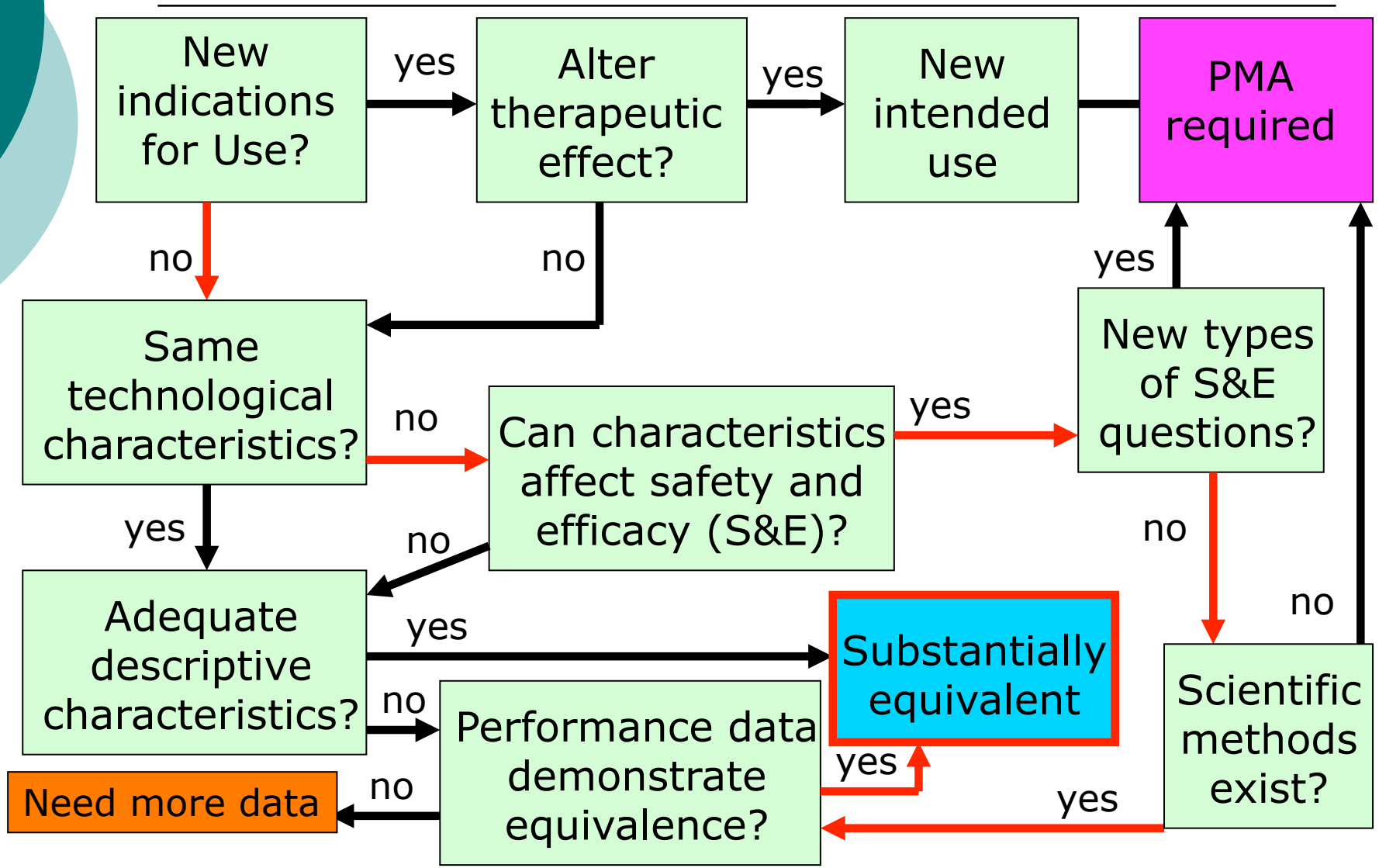
Safety and Efficacy Question	Radiation modification of material	Crystallinity
Scientific Method	Swell ratio, TVI	Thermal properties

See ASTM F2565

XLPE Functional Testing

Safety and Efficacy Question	Wear rate	Liner/Cup interlocking	Rim fracture
Scientific Method	Hip simulator testing	Push out, lever out, torque out testing	Rim fatigue testing

XLPE Example



Vit. E XLPE Example

- Device modification: 0.1 wt% Vit. E before molding, 100 kGy irradiation followed by anneal (120 °C), EtO sterilized
  - Same head/liner dimensions
  - Same liner/cup locking mechanism
- Predicate device: XLPE hip system (100 kGy, remelted, EtO sterilization)
- Indications: Same as predicate

Vit. E XLPE Material Testing

Safety and Efficacy Question	Tensile properties	Oxidation resistance	Fatigue resistance
Scientific Method	Tensile testing, small punch testing	Accelerated aging after loading and after extraction, OI, free radical content	Fatigue crack propagation testing, Izod impact test

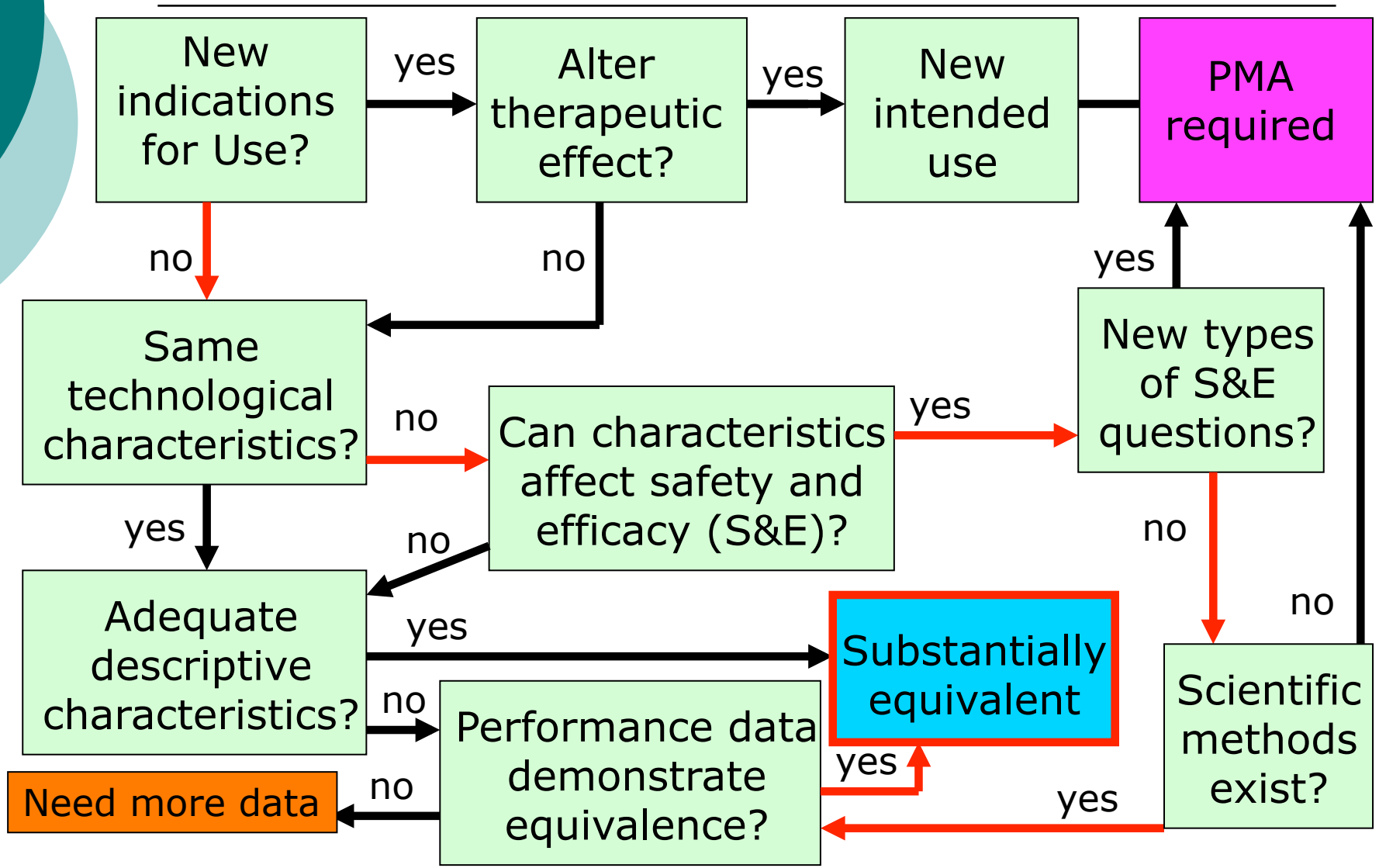
Vit. E XLPE Material Testing

Safety and Efficacy Question	Modification of material	Biocompatibility
Scientific Method	Swell ratio, TVI, VEI, consolidation verification, thermal properties	Exhaustive extract analysis (GCMS, LCMS), toxicological risk assessment, cytotoxicity, sensitization, irritation, acute toxicity, chronic toxicity, genotoxicity, implantation, and carcinogenicity

Vit. E XLPE Functional Testing

Safety and Efficacy Question	Wear rate	Liner/Cup interlocking	Rim fracture
Scientific Method	Hip simulator testing (normal & abrasive), wear particle analysis	Push out, lever out, torque out testing	Rim fatigue testing

Vit. E XLPE Example



Summary

- All medical devices were originally sorted into three classes according to risk
- New moderate risk devices are those that can rely on the proven clinical history of substantially equivalent moderate risk devices
- Devices are deemed high risk when they are not substantially equivalent to marketed devices with clinical history
- Devices that employ technological characteristics that raise new types of safety and effectiveness questions cannot rely on another device's clinical history

Questions?