This guidance was written prior to the February 27, 1997 implementation of FDA's Good Guidance Practices, GGP's. It does not create or confer rights for or on any person and does not operate to bind FDA or the public. An alternative approach may be used if such approach satisfies the requirements of the applicable statute, regulations, or both. This guidance will be updated in the next revision to include the standard elements of GGP's.

GUIDANCE DOCUMENT FOR THE PREPARATION OF PREMARKET NOTIFICATIONS FOR CERAMIC BALL HIP SYSTEMS

D R A F T

January 10, 1995

PLEASE FORWARD YOUR COMMENTS TO:

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CONTENTS

PREFACE

The FDA has reclassified the hip joint metal/ceramic/polymer semi- constrained cemented or non-cemented prosthesis (referred to in this document as ceramic ball hip system) from class III (premarket approval) into class II (performance standards) (see Federal Register, vol. 53, No. 103). A premarket notification (510k) must be submitted by all distributors of ceramic balls and hip stems labeled for use with a ceramic ball.

The purpose of this document is to recommend to the device manufacturer or sponsor of premarket notifications (510(k)), Investigational Device Exemption (IDE), Premarket Approval (PMA), reclassification petition, or master file important information that should be submitted to FDA in order for FDA to determine the substantial equivalence and/or safety and effectiveness of hip systems which may include a ceramic ball. The development of this guidance document was based on data in a reclassification petition filed by PROTEK, Inc., Indianapolis, IN, and on the evaluation of the literature concerning ceramic ball hip systems by the Division of Surgical and Rehabilitation Devices (DSRD) . It suggests some important evaluation criteria, test procedures, and end points that FDA feels are necessary to provide reasonable assurance of substantial equivalence and/or safety and effectiveness of ceramic ball hip systems. Although this guidance document contains certain administrative requirements, it does not replace the requirements of the 21 CFR 801 or 807 or the statue.

FDA may require information in addition to what is contained in this document if circumstances require it. In other instances, the sponsor may be able to sufficiently justify the omission of some tests. Suggestions and recommendations presented in this document are not mandatory requirements, but reflect data and methodologies which ORDB has determined to be acceptable. Therefore, the words "should", "must" and "shall" are not used in a regulatory sense and should not be construed as such. They express FDA's current feeling as to what constitutes good scientific decision making.

The guidance document should be viewed as a living document. As scientific knowledge changes and scientific techniques are improved, FDA will revise the document. Nonetheless, the basic objectives will remain the same.

IDENTIFICATION OF THE STEM

The following must be tabulated for each stem having the cone design and ceramic balls specified below:

1 the names,

2 510k or PMA numbers,

3 a drawing or photograph,

4 materials composition, standard number, trade name and original manufacturing source,

5 documentation of substantial equivalence or approval (e.g., a copy of the letter from FDA),

6 a brief description of the design and main processing methods (e.g., wrought, porous sintered coating, nitrided, radiation sterilized),

7 whether the stem was cleared for cemented use only, and

8 the model numbers of each ceramic ball to be used with each stem.

CONE DESIGN

A table or dimensioned engineering design drawings must be provided which include tolerances for the following dimensions:

1 angle,

2 length,

3 diameter,

4 straightness,

5 surface texture (e.g., machined grooves),

6 surface roughness,

7 length of ball/cone overlap,

The table or dimensioned engineering design drawings must include all:

A. cone tapers of all stems under consideration, and

B. cone trunions evaluated in the tests listed below.

IDENTIFICATION OF THE BALL

The following should be tabulated for the ceramic balls identified above:

1 the names and manufacturer model numbers,

2 known MAF, 510k and PMA numbers in which each ball was cleared for marketing and documentation of substantial equivalence or approval, and

3 material composition, standard number, trade name and names of establishments processing and providing the main ingredients.

The following must be provided regarding surface engravings:

1 magnified photos of any engravings on the ball,

2 an evaluation of any surface changes (e.g., phases) and defects (e.g., cracks, pits) in and around the engraving, and

3 a description of the engraving process and the point in the manufacturing of the ball where the engraving is made.

The following information on radioactive isotopes must be provided:

1 concentrations as determined from the spectra and intensity of the radiation;

2 half-lives;

3 sample size;

4 effect of the sample size on the measured radiation dose;

5 significance of the measured radiation level in the material, determined by demonstrating that the radiation level is equal to or less than the radiation level in a biocompatible, clinically accepted material, or causes no biocompatibility problems in humans for at least 15 years.

A letter of access from the ball manufacturer must be submitted to FDA for all ceramic balls which were not previously approved or found substantially equivalent. The letter of access must give FDA permission to examine data in the master file pertaining to the ceramic balls identified in the labeling of the stem.

BALL DESIGN

Dimensioned engineering drawings and tolerances for the following parameters must be provided for all ceramic balls which were not previously approved or found to be substantially equivalent. The values in parentheses are the boundaries of the reclassified ceramic ball hip system. A system does not have to be within these bounds to be determined substantially equivalent if the mechanical test results are adequate.

1 Bore angle (the bore angle is greater than the cone angle to assure that the cone-ball contact area is adequate).

2 Bore length (the stem/head length of overlap is greater than 50% of the axial length of the bore).

3 Bore diameter at the top and bottom of the taper.

4 Bore straightness (< 3 microns).

5 Bore surface roughness (no requirements).

6 Articulating surface roughness (Ra < 0.2 microns).

7 Sphericity (< 5 microns).

8 Diameter (no requirements).

9 Defects (no defects on any part of the surface of any ball > 0.5 microns).

The following must be provided for alumina balls:

1 Grain size (< 5 microns).

2 Purity (> 99.7% aluminum oxide).

3 Composition (maximum percentage for each of the following trace elements is:
MgO .2
SiO_2 .01
CaO .03
Na_2O .02
Fe_2O_3 .03
TiO_2 .01)

4 Specific gravity (> 3.94 g/cm^3).

The following must be provided for zirconia balls:

A description of the critical manufacturing methods, QC tests and pass/fail criteria must be provided.

MECHANICAL TESTING

Each hip stem cone with a unique set of dimensions and tolerances, materials and design must be mechanically tested with either:

1 all ball models with which the stem will be labeled for use, or

2 the ball model having the highest critical stresses under all possible clinical loading conditions. However, it must be demonstrated that each of the other ball models under consideration will experience lower stresses under the same conditions.

Once a particular cone with a specified set of dimensions and tolerances has been cleared for use with a particular ball, other stems from the same manufacturer with the same set of cone dimensions and tolerances will not require mechanical testing.

A statement should be provided to the effect that the balls and cones which were mechanically tested, were representative of the design tolerances of the product shipped for clinical use and that ceramic test specimens had the same composition and structure (e.g., grain size, density) as the ball. All deviations from this statement must be listed and explained. The test result for each specimen must be provided and all specimens chosen for testing must be identified.

FDA may require additional mechanical tests for cone and ball designs whose mechanical performance can not be adequately predicted from the design specifications and mechanical tests listed in this document.

STATIC COMPRESSION

A random sample of at least 5 balls of each combination shall be loaded axially in compression to failure following ISO 7206-5. The load may be applied to the ball through a copper ring or an equivalent method of loading (e.g., an appropriate copper ring to load a 32 mm ball would have a 1" O.D., 0.800" width and 0.055" thickness).

A detailed test report on static compression to failure must be provided. A copy of the entire report should be included in the 510k even if the same cone and ball designs were cleared in other documents. Each data point must identify the manufacturer and model numbers of each ceramic ball which was tested on the stem. The cone trunions mechanically tested must be identified as outlined above under CONE DESIGN.

The average fracture strength of the balls shall exceed 46 KN. No ball shall fail at less than 20 kN.

NEW BALL MECHANICAL TESTING

A ceramic ball made of a new material or manufacturing process or produced by a new manufacturer may require the following mechanical test data in addition to static compression to failure:

1 Balls shall be cycled axially between constant minimum and maximum compressive loads on a stem cone (trunnion) out to 10^7 cycles following ISO 7206-5. The load shall be applied to the ball through a copper ring or an equivalent method of loading (e.g., an appropriate copper ring to load a 32 mm ball would have a 1" O.D., 0.800" width and 0.055" thickness). The minimum load shall be $\leq$ 10% of the maximum load. At least 3 balls shall be cycled to a maximum load of at 14 kN. All balls which do not fail shall be inspected for cracks and then fractured in static compressive loading. There shall be no cracks or ball fracture after 10^7 cycles and no post-fatigue static compression failures below 20 kN. Unless data is available demonstrating no adverse effects of physiological solutions on the properties of the ball, each ball must be aged 4 weeks in a simulated physiological solution at 37^o C prior to fatigue testing and kept moist during fatigue testing.

2 Axial pull-off loads shall be measured on at least 5 ceramic balls attached to the cones with a 2 kN preload.

3 The flexure strength of the ceramic shall be reported using ASTM C674 or an equivalent method.

4 Hardness shall be reported using ASTM E384, ISO 6507 or an equivalent method.

5 Wear rate of both the ceramic ball and PE cup.

6 Hardness of the ceramic material.

7 Elastic Modulus of the ceramic material.

8 Impact

LABELLING

The labeling for each stem must identify the manufacturer and model or catalogue numbers of each ceramic ball to be used with the stem. The labeling for the ball must state that the ball will be used only with stems labeled for use with the ball and that the stem labeling should be consulted to determine which stems are compatible with the ceramic ball. This allows the use of future hip stems with a ceramic ball without altering the ball labeling. It would also be appropriate to include the following in the ball labeling:

1 The ball must not be sterilized on the hip stem.

2 Autoclaved balls should not be cooled rapidly.

3 The stem cone and ball bore should be dry and free of contamination.

4 A ceramic ball should not be implanted if the ball or the cone of the stem are possibly damaged (e.g., if the ball is dropped on the floor or if the stem cone is scratched by an instrument or if the ball and stem cone are attached then detached).

5 The ball should be placed on the stem cone gently while keeping the ball and cone in alignment, then firmly attached by sharply hitting the ball with a soft plastic hammer.

Zirconia balls must contain the following labeling:

1. The contraindications of the labeling must include: "The Zirconia Ceramic Head is contraindicated for use with any other than an UHMWPE cup or a metal backed UHMWPE cup."

2. The Warnings and Precautions of the labeling must include: "The Zirconia Ceramic Head is composed of a new ceramic material with limited clinical history. Although mechanical testing demonstrates that, when used with polyethylene acetabular cups, the partially stabilized Zirconium ball produces a relatively low amount of particulates, the total amount of particulate remains undetermined. Because of the limited clinical and preclinical experience, the long term biological effects of these particulates are unknown."

OTHER INFORMATION

FDA may require additional testing for cone and ball designs whose performance can not be adequately predicted from the design specifications and tests listed in this document.

Clinical data may be accepted in support of but not in place of mechanical data since the mechanical properties of a stem-ball system may be inferior to that approved in the petition, yet still not demonstrate ball fracture or wear in clinical studies.

TEST REPORT CONTENT

Detailed reports should be organized and subdivided into separate sections (some sections may be combined to enhance clarification) having (if applicable) the following headings:

Can you provide the following?:

clinical fracture rate (number fractured/number implanted) of each type of ceramic ball (material, diameter, neck length)

evidence that a smaller ball is normally used in a lighter patient

copy of iso 6474

cracking or phase changes due to surface engraving

methods of evaluating radioactive isotopes

a list of material requirements for zirconia balls