Clinical performance and bearing surface morphology of a total hip replacement implant after 9 years of in-vivo service

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Background

Total hip replacement (THR) is highly effective in reducing pain and improving mobility in osteoarthritis (OA). In humans, THR longevity is often limited by implant wear, osteolysis and aseptic loosening.

In humans, vigorous athletic activity after THR may shorten the lifespan of implants [2]. This is a concern in canine THR because of the growing trend towards performing surgery in younger dogs. There has been only one detailed retrieval study on canine THR implants, with this documented wear and articular surface damage of the acetabular components implanted for up to 12 years [1]. However, that study did not explore the relationship between exercise level and implant wear. With the increased availability of components implanted for up to 12 years [1], this question in greater detail.

Objective

The goal of this case study was to document a detailed retrieval analysis on a THR implant after 9 years of active in-vivo service including clinical performance, imaging, histology and tribology.

Materials and Methods

Case Report

- 8.3 years old, 20kg (IUC 6/9), female spayed Catahoula mix breed (Fig 1), diagnosed with severe bilateral hip dysplasia and presented with a 5 month history of progressive left pelvic limb lameness.
- Left cemented THR performed.
- Routine post-operative rehabilitation period monitored by annual radiographic rechecks.
- Dog’s activity was recorded daily by the owner using activity monitors.
- Patient was euthanized 9 years after THR.

Retrieval Preparation

The left hemispheric and left femur were explanted and musculature was removed, leaving the periprosthetic tissue and capsule intact. The femur was cut transversely distal to the femoral stem. The specimen was preserved in 10% formaline.

Imaging

- Orthogonal radiographs were taken of the hip and lateral radiographs were taken of the left distal femur.
- Microscopic images of the femoral head surface were taken using an optical microscope (Olympus BX51, Olympus, Southampton, UK, UK) with a x10 objective.

Histology – periprosthetic tissue and joint capsule

- Tissue was routinely processed for histological analysis and stained with haematoxylin and eosin.

Tribological analysis – implanted acetabular cup and femoral head, and age-matched non-implanted acetabular cup (25mm CPY) and femoral head (17mm)

- Profile measurements were made with a contact profilometer (Talysurf 125, Taylor Hobson, Leicester, UK) using a recess ball stylus with a 0.5 mm radius tip. Data were imported into Matlab and a circle fitted to each of the profiles.
- Roughness measurement of the femoral head were made with a white light interferometric profilometer (Zygo, Newington, CT, USA) using a 20 μm lens; roughness measurements of the acetabular cup were made with a contact profilometer (Talysurf 125) using a recess conical stylus with a 20 μm radius tip.

Post-operative Clinical Period

- Implants and cement used: 23mm acetabular cup, size 7 collagen femoral stem, 17mm-0 femoral head (CFX, BioMedtrix LLC, Whippany, NJ), cemented with Surgical Simplex bone cement (Stryker, Mahwah, NJ).
- Surgery time: 80 mins, no intra-operative or immediate post-operative complications, excellent implant positioning, discharged 2 days post-op.
- After uneventful recovery, the dog returned to an active lifestyle after surgery, running over 9000 miles on the operated hip (verified by owner log books).
- On animal orthopedic follow-up the dog was pain-free and showed increased and sustained muscle mass on the left pelvic limb.
- Radiographic follow-up did not show any implant related complications (Figs 2, 3).

Figs 2, 3. Ventrodorsal extended pelvic radiograph (Fig 2) and mediolateral femoral view (Fig 3) 7 years postop, showing good implant positioning and presence of good cement mantle.

Radiographic and macroscopic evaluation of the hip explant

Fig 4. Radiographic images of the explanted hemipelvis with transsected femur in mediolateral and axial projections revealed good implant positioning, good cement mantle and no signs of implant-related complications.

Fig 5. Macroscopic evaluation of the cut acetabular surface showing good bone-cement-implant apposition.

Fig 6-8. On macroscopic evaluation the used femoral head and cup appeared smooth (Fig 6); on microscopic evaluation the used head had many small scratches running in all directions (Fig 7) while the new head was smooth and featureless (Fig 8).

Discussion

Profilometry revealed excellent congruency between cup and femoral head. The fit was excellent over the main contact area and only showed significant deviation at the edge of the cup. The different features seen in the contact regions of the cup probably correspond to different wear regions in the cup. Metal-on-plastic (MOP) articulations operate with boundary lubrication, a condition in which a complete fluid film does not develop between apposition surfaces, leading to more wear due to momentary direct contact between wear surfaces, explaining these findings.

The used femoral head was rougher than the new head, but still has a smooth polished surface finish by engineering standards and exhibited small scratches only on microscopic images. The surface of the new acetabular cup was rougher than the surface of the used cup, an observation that is likely due to “shock loading” in which the softer asperities on the cup are worn away by the metallic counterface, leading to the release of wear debris. Polymer particles have been found incorporated in denatured proteins building a layer between articulating surfaces in MOP THR retrievals [3].

The histopathological findings are consistent with particulate wear debris leading to a foreign body reaction in the periprosthetic tissue, but the response was not severe enough to lead to clinical signs or implant failure. Adverse local tissue reaction has been shown in people [4] and dogs [5] after failed MOP THR, but no reports are available investigating periarticular histology of complications-free THR in dogs.

In contrast to a previous study [6], no macroscopic or radiographic sign of implant loosening at the implant-cement or cement-bone interface was detected. A complete description of the tissue response will require detailed examination of the cement-bone and/or implant-bone interface.

Conclusions

This cemented metal-on-plastic THR implant provided a robust, long-term solution, even in the face of sustained, high level activity for 9 years after surgery. When combined with data from clinical registries, retrieval studies like this will be useful in determining longevity, implant wear and the risk of aseptic loosening in dogs implanted with current and novel implant systems.

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Literature Cited


Figs 4, 5. Deviations (mm) from the circular fit of the cup measurements are shown for the new (Fig 4) and used cup (Fig 5). Lines correspond to the traces measured from the centre to the edge of the cup. In the used cup a groove (a) and a ridge (b) was found representing different wear regions in the cup.

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