Wear Assessment of a Novel Squeeze-Film Artificial Hip Joint

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Motivation
• Excessive wear in conventional total hip replacements (THR) is linked to an inadequate lubrication mechanism to separate cup and ball surfaces due to:
  - low-amplitude ball oscillation under non-reversing gait cycle load, resulting in poor wedge-film lubrication
  - spherical ball and cup geometry, resulting in low film thicknesses and high film pressures concentrated over limited area approaching point contact

Features of Design
• Novel hip joint design employs lubricant squeeze film action (instead of wedge-film action) to maintain surface separation during the (high-load) stance phase of the gait cycle
  - Elastic columns provide a means of separating ball and cup surfaces during the (low-load) swing phase of the gait cycle
  - Substantially larger film thicknesses and substantially lower film pressures are predicted for the novel THR than for all current designs

Predicted Results
• The novel design without a coating shows improvement over the conventional design in volumetric wear, but linear wear rate is very high
  - The novel design with a 0.2 mm coating shows significant improvement over the conventional design in volumetric wear (75%) and a reasonable linear wear rate
  - Estimated lifetime of the 0.2 mm coating is approximately 11 years

Characterization of Wear
• Since the elastic columns contact the ball during the entire gait cycle, the wear characteristics of the elastic elements are an integral component of this research
  - An Archard-based wear formulation that relates contact pressure (found using finite element analysis) and sliding distance to linear wear depth is applied to the novel design
  - The low-modulus elastic elements are modified with a bonded high-modulus coating on the contact surface to decrease linear wear depth on the columns
    - This alternative design is compared with a metal-on-metal conventional model
      - The ISO 14242 standard, which specifies gait cycle loading and kinematic conditions for hip simulator testing, is applied to the finite element models