Surveillance of Dual-Mobility Hip Systems: Damage Mode and Clinical Data Analysis

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Introduction

Background

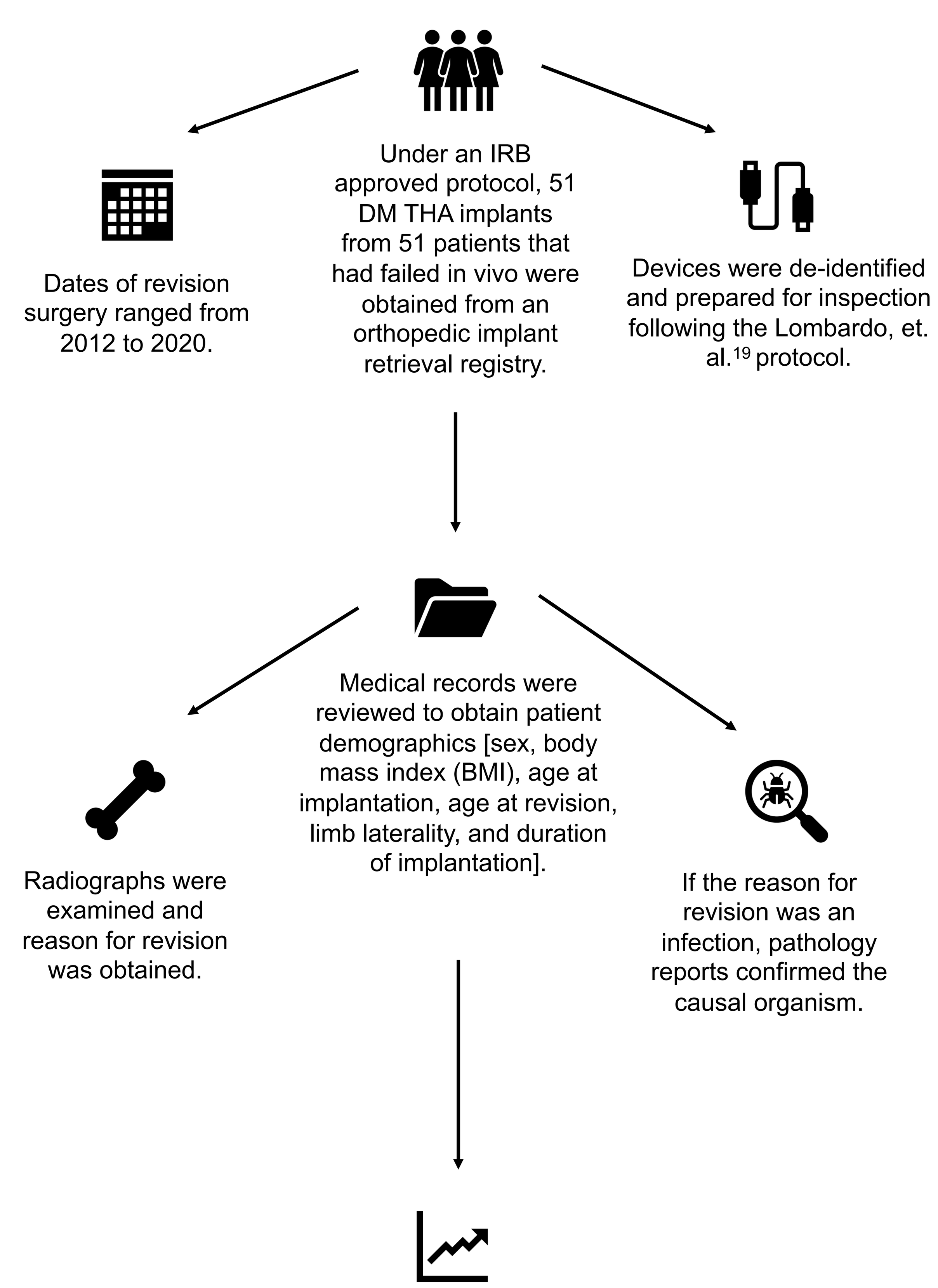
- Dual mobility (DM) total hip arthroplasty (THA) systems are designed to decrease dislocations, increase range of motion, and provide long-term stability.[1,2]
- Since receiving FDA approval in 2009, the use of DM constructs has steadily increased for both primary and revision THA.[3,4]
- Heckmann et al. queried the American Joint Replacement Registry from 2012 through 2018, analyzing 406,000 primary and 34,745 revision THA, reporting 35,455 primary and 8,031 revision THA where DM implants were used.
- DM constructs in primary cases increased from 6.7% to 12%, while DM constructs in revision cases increased from 19.5% to 30.6%.[4]
- Implant revision risks are reported to be significantly lower in DM patients, with all cause survival rates up to 94.5% and aseptic survivorship up to 97.7% in a recent meta-analysis.[5]
- While these outcomes are encouraging, the clinical utility of DM constructs improving dislocation rates has been contested, with a recent study reporting up to 11% dislocation rates[6] and another showing no significant difference in dislocation rates compared to traditional THA when using large (≥40 mm) femoral heads and an anterior approach.[7]
- Furthermore, corrosion at modular interfaces has become a topic of fierce scientific exploration over the past 5-10 years with many studies investigating possible sources, damage modes, and severity in DM systems.[6,8-18]
- A retrieval study published by our colleagues demonstrated that DM THA systems may be susceptible to the same fretting and corrosion damage observed in traditional THA systems.[19]
- Furthermore, the novelty of screw ring damage to metal inserts was noted in this previous study and a retrieval study published by Sutter et al.[15]

Aims and Objectives

- To provide an updated assessment of DM THA systems retrieved in Lombardo, et. al[19] by analyzing all new DM implants added to the registry at our institution since its publication
- Overall, these analyses will provide additional considerations for orthopedic surgeons when determining whether to use DM THA as an alternative to traditional THA systems.

Methods

Data Collection



Each implant component (acetabular cup, metal insert, PE liner, femoral head, and femoral stem) was analyzed for visible damage modes (abrasion, burnishing, delamination, dishing, edge deformation, embedding, scratching/grooving, and pitting) on articular and backside surfaces, which were carefully distinguished from iatrogenic deformations.[9,20]

Fretting and corrosion were graded using the following scale from Goldberg et al: none (1), mild (2), moderate (3), and severe (4), consistent with multiple orthopedic retrieval studies.[21-28] Femoral heads were divided into proximal and distal regions. Femoral necks (male taper) were divided into four anatomical quadrants (superior, inferior, anterior, and posterior). Total score sums for fretting and corrosion ranged from 2 to 8 and 4 to 16 for femoral heads and necks, respectively.

Statistical Analysis

Statistical analyses were performed using SigmaPlot 11.0 (Systat Software, Inc, Chicago, IL). Results were considered statistically significant if P-values < 0.05.

Results

Patient Demographics

Patients were predominantly female (32 of 51, 62.7%) with an average age of 64 years (range, 34-96; n= 51) at the time of DM implantation and 64 years (range, 38-97; n=51) at the time of implant failure and revision surgery. The average duration of implantation was 12 months (range, 3 days-72 months). Patient BMI was 29 on average (range, 19-49) kg/m^2. Of the 51 retrieved DM THA systems, 26 (51%) were from the right hip and 25 (49%) were from the left hip.

Reason for Revision	# of Patients*	% of Patients
Mechanical complication	15	27%
Infection	12	22%
Dislocation	9	16%
Periprosthetic fracture	6	11%
Pain	5	9%
Acetabular-associated loosening	2	4%
Hematoma	2	4%
Seroma	1	2%
Inflammatory reaction	1	2%
Limb length discrepancy	1	2%
Unknown	1	2%

Table 1: The reasons for implant revision documented in patient medical charts are listed in descending order of frequency. *Four patients had two reasons documented in their medical chart.

Standard Damage Mode Analyses

Figure 1: Macroscopic Damage Modes on Articulating Surfaces

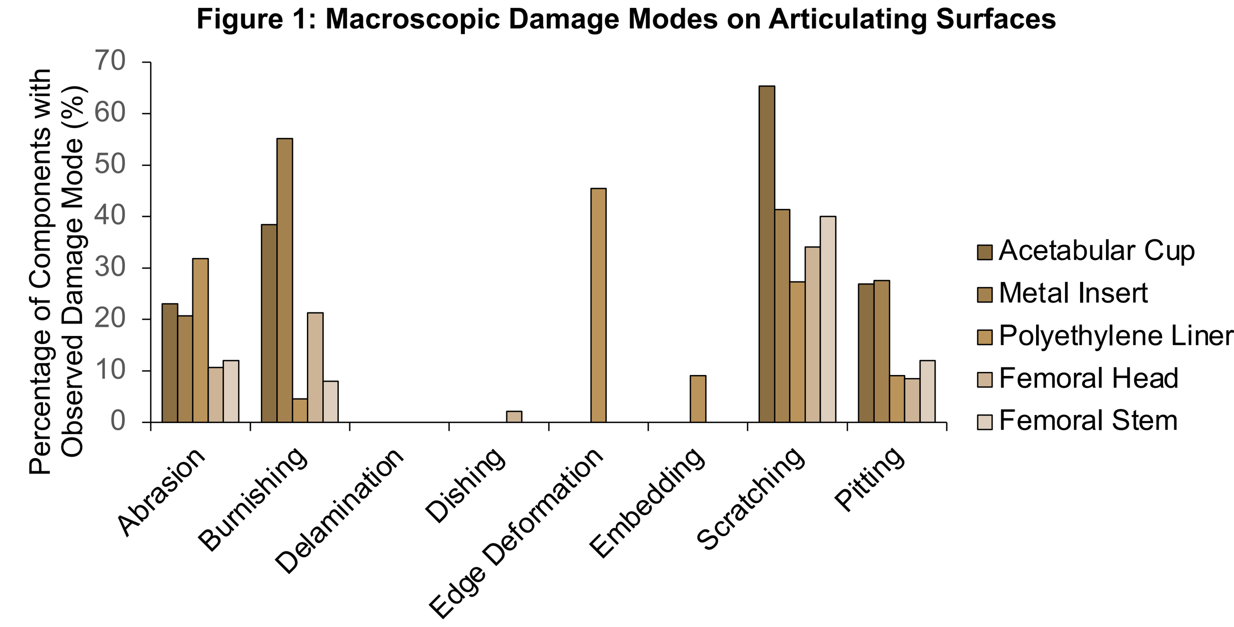


Figure 1: Damage mode frequency by component articular surfaces. Number of surfaces analyzed varied by component availability and separation of components, including acetabular cup (n=26), metal insert (n=29), polyethylene liner (n=22), femoral head (n=47), and stem/trunnion (n=25).

Figure 2: Macroscopic Damage Modes on Backside Surfaces

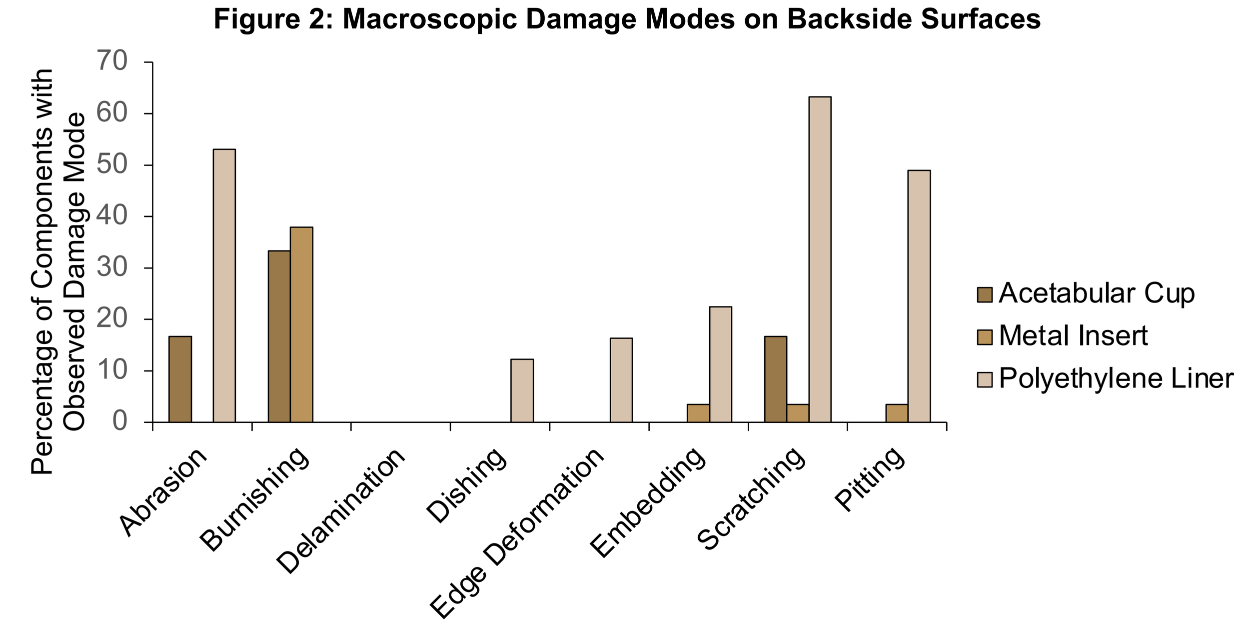


Figure 2: Damage mode frequency by component backside surfaces. Number of surfaces analyzed varied by component availability and separation of components, including acetabular cup (n=6), metal insert (n=29), and polyethylene liner (n=49). Discrepancies in the number of articulating and backside surfaces examined were due to component fixation.

Results Cont. & Conclusion

Fretting and Corrosion Data Analyses

Fretting was defined as mechanical damage to the surface that may have resulted in material removal, plastic deformation, and regions of increased reflectivity. Corrosion was defined as regions of discoloration or decreased reflectivity. Thirty-three explants had CoCr femoral heads and 24 had femoral stems available for assessment. Thirteen explants were not assessed because they had ceramic heads and no stem. The summed fretting and corrosion grades were very strongly, positively correlated for both the heads (rho=0.818, P < 0.001) and the trunnions (rho = 0.810, P < 0.001).

Figure 3: Summed Fretting and Corrosion Grades

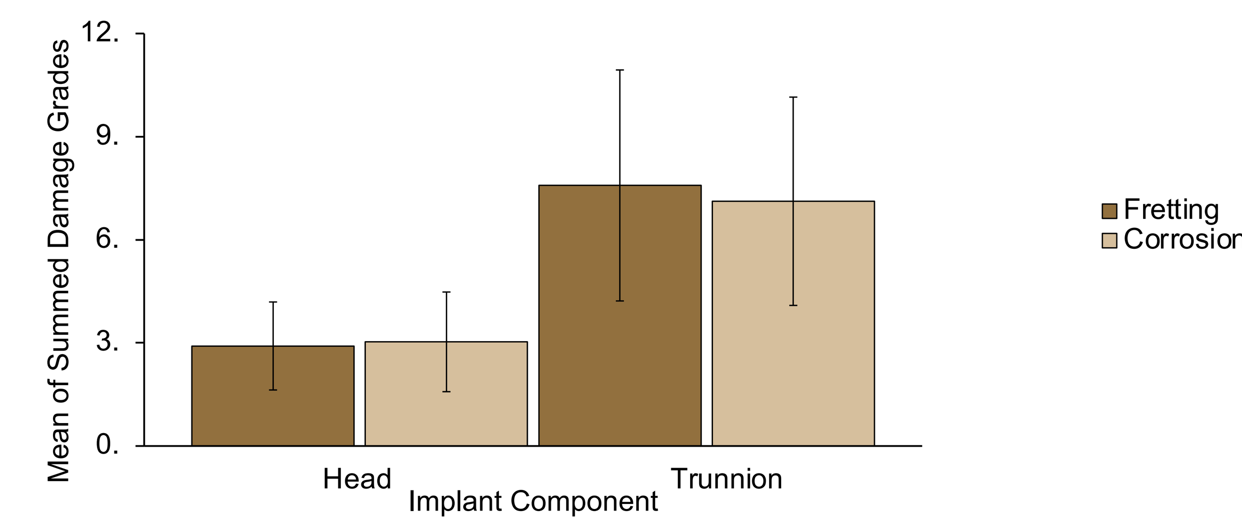
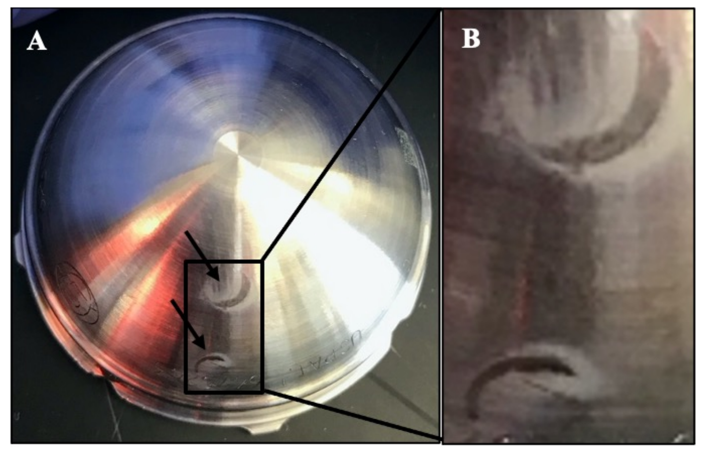


Figure 3: Average summed head fretting, head corrosion, trunnion fretting, and trunnion corrosion from retrieved dual-mobility total hip prostheses, showing average summed scores for the head taper (score range, 2-8) and neck trunnion (score range, 4-16).

Screw Ring Damage

Screw ring damage is a finding that was first discovered in Lombardo et al., where one acetabular metal insert demonstrated fretting damage from titanium screw metal transfer.[19] In our expansion of this study, two additional metal inserts were found with the same descriptive damage, making the incidence 10.34% (n=3/29) within our updated retrieval registry. When screw ring damage was present, there were more instances of acetabular and femoral osteolysis (p=0.019 and p=0.022, respectively).



Conclusion

In summary, our study built upon the findings of Lombardo et al., characterizing both the macroscopic and microscopic damage modes involved in DM THA systems and resultant component wear. Given the negative effects of trunnionosis and eventual adverse local tissue reaction, we feel it is paramount to report and characterize these wear patterns in DM THA systems.[8]

References & Acknowledgements

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