What are the Possible Reasons for the Early Implant Failure? Preliminary Outcome from the Retrieval Analysis

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INTRODUCTION: According to an article published in *Arthroplasty Today* in 2023, the number of revised total hip arthroplasties (THA) is projected to double by 2040 compared to 2020[1]. From 2012 to 2019, over 500,000 revision total knee arthroplasties (TKA) were conducted nationally[2]. Infection, loosening, and mechanical problems have been attributed as causes for the failure of THA and TKA[3,4]. Therefore, recognizing the high volume of and need for revision THA and TKA nationally, it is crucial to further analyze the causes of hip and knee replacement failure to better enhance the success and shortcomings of joint replacement in clinical patient outcomes. The purpose of this study is thus to collect samples of failed hip and knee orthopedic implants from surgeons and analyze the features of those implants to find possible pathological reasons of implant failure so that these causes can be successfully prevented and/or mitigated.

METHODS: Implants, obtained from UIC (IRB:00000688-UIC), ready to be examined, were cleaned according to a protocol developed at Rush University Department of Orthopedic Surgery that consisted of soaking implants in a 10% neutral buffered formalin solution for at least 3 days to decontaminate them. Implants were then rinsed in running tap water for 15 minutes and allowed to air dry on a counter overnight. Any implants requiring further cleaning to visualize damage patterns were cleaned using a soft toothbrush under warm water. Implants with adherent protein films were cleaned with 1% Tergazyme in an ultrasonic cleaner. After cleaning, implants were stored in labeled containers at room temperature. Microscopic imaging using Unitron MEC3 at magnifications 5x, 10x, 20x and 50x allows for scanning the implant. For implants with non-flat surfaces, multiple images were taken at each section. IRB approval was obtained for this study.

RESULTS: Samples 1, 2, 4, 5, 6, 7, 8, 10, 11, and 13 were knee implants, whereas samples 9, 12, and 14 were hip replacements. The representative images from the retrieval analysis is presented in **Fig (a-d)**, Sample 1 exhibited some pitting and abrasions when it was retrieved due to instability. Sample 2 was removed because of discomfort, stiffness, and limited range of motion. Sample 4 was seen with abrasions when it was removed because of a periprosthetic fracture and persistent hip discomfort. Sample 5, retrieved due to right knee dislocation, had scratches on its surface. Sample 6 contained adhering bone structures was discolored and disintegrated. It was removed because the right knee had dislocated. Sample 7, which was retrieved during a complete knee arthroplasty due to arthrofibrosis, was free of any visible marks or defects.

Samples 8,10 and 11 were removed due to chronic knee pain. Sample 8 contained adhering bone structures that were 2-3 mm thick and abrasions and scratches. Along with bone structures and abrasions, peeling and disintegration of the plastic liner component was observed in samples 10 and 11. Sample 13 also had bone structures adhered to it. Sample 3, which was retrieved due to periprosthetic fracture and chronic hip pain, had discoloration and scratch marks. Sample 9 contained adhering bone structures, abrasions/scratches, and discoloration when it was removed because of persistent hip discomfort. There were scratches and abrasions on samples 12 and 14.

DISCUSSION: The findings suggest that a combination of factors, including material, design, patient, and surgical factors, contribute to total hip and knee replacement failure. Mechanical trauma to the implants is a likely contributing factor to hip and knee implant failure, as scratch marks and abrasions were common in the implants collected (**Fig (e)**). Disintegration of the implants could also be a factor, as seen in the peeling present. Surrounding bone structure obstructing implants (e.g., adherent bone structures) from the tibia, fibula, and/or other bones could also be a factor. Further research is needed to investigate these factors in more detail as per the Goldenberg scoring and to develop strategies to improve the success of these procedures. It is crucial to recognize that the depth of this study is limited due to the small number of implants, which thus limits the generalizability of this study to the national population. Also, patient lifestyle factors such as exercise, sedentariness, and smoking were not examined. Hence, additional research is needed with a larger number of implants and from a wider population of surgeons.

SIGNIFICANCE/CLINICAL RELEVANCE:

The underlying principle of our proposed work is to use retrieval analysis to investigate failure mechanisms or improvement of existing implants, as well as the development of future products. The findings of this study provide valuable insights into the factors that cause failure in hip and knee replacement surgeries and open doors for further research in this area.

REFERENCES:

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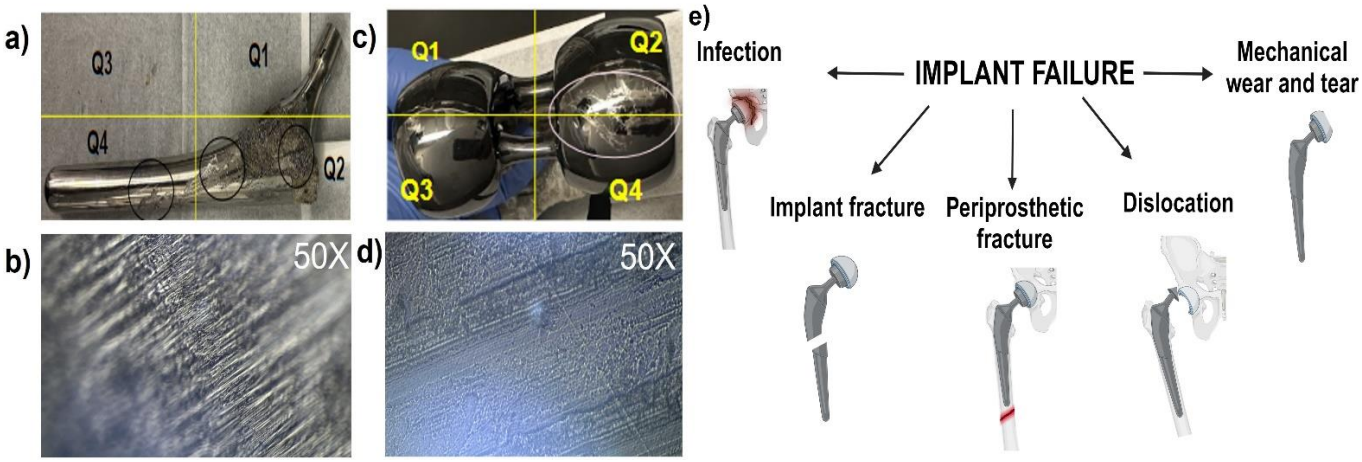

Figure 1. Implant images and possible failure mechanisms. (a) Sample 9- Hip implant with abrasions, (b) Sample 9 abrasions under Unitron MEC3 50X microscopic magnification, (c) Sample 6 - Knee implant with scratches, (d) Sample 6 scratches under Unitron MEC3 50X microscopic magnification, (e) A diagram showing possible causes of implant failure.