

Retrieval Analysis of Polyethylene in Total Knee Arthroplasty in Thailand: A Case Report

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ABSTRACT

Objective: Retrieval analysis is one of the effective methods that can provide the information on in-vivo characteristics of wear implants. The clinicians can correlate the damage pattern from this method with other findings in a reproducible manner. Nevertheless, there has been no previous retrieval analyses of PE wear in total knee arthroplasty (TKA) in Thailand.

Case Presentation: A 80-year-old female underwent left TKA due to osteoarthritic knee in 1994. She was 135 cm in height and weighed 42.7 kg. The cemented posterior stabilized press-fit condylar (PFC) (Depuy, Warsaw, IN, US) total knee system was used. Patellar resurfacing was performed with a cemented all-polyethylene implant. The femoral component was cobalt-chrome, while the tibial component was titanium alloy. A 12.5-mm thickness of stabilized plus tibial insert was used.

After surgery, her knee had functioned well for 20 years. One year ago, she had intermittent swelling and effusion of the knee, together with occasional pain. The symptoms had gradually progressed with increasing episodes of giving way. She was diagnosed with aseptic loosening of TKA and consequently underwent revision TKA in 2014. All components were removed and retrieval analysis of PE tibial insert was performed at the National Metal and Materials Technology Center (MTEC), Thailand.

Wear assessment of the articulating and non-articulating surfaces was performed in 16 zones. We found that PE wear was present in 11 zones without any backsides wear. The stereomicroscopy was performed, in which the scratches and delamination of the PE surface were demonstrated. The specimen was cut and analyzed using a scanning electron microscopy (SEM) to observe the insides of PE. Delamination, subsurface cracking and damage were identified in the damaged zones. In the metal part of PE, the surface damage and metal wear debris were also displayed using SEM.

Conclusion: This retrieval analysis could demonstrate various modes of wear on UHMWPE. However, we propose that future studies, which are based on the association between wear of UHMWPE and possible precipitating factors, are mandatory.

Keywords: Retrieval analysis; mode of failure; fail total knee arthroplasty; wear assessment (Siriraj Med J 2018;70: 175-177)

INTRODUCTION

Total knee arthroplasty (TKA) is one of the most effective orthopaedic procedures for treating end-staged osteoarthritic knee. However, this artificial joint has limited longevity. The common modes of failure after

TKA include aseptic loosening, polyethylene (PE) wear and infection.¹ In TKA, PE wear and debris are the major concerning problems, which can cause osteolysis and lead to aseptic loosening. There are several factors that are related to the PE wear such as PE processing, implant

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design, patient factors and poor surgical technique.²

The delamination, pitting and fatigue failure of PE have been reported in previous literature.^{3,4} Third-body wear can also occur from bone cement or bone fragments. Retrieval analysis is one of the effective methods that can provide the information on in-vivo characteristics of wear implants. The clinicians can correlate the damage pattern from this method with other findings in a reproducible manner. Nevertheless, there has been no previous retrieval analyses of PE wear in TKA in Thailand. This is the first report that can guide further retrieval analyses of artificial joint replacements.

CASE PRESENTATION

An 80-year-old female underwent left TKA due to osteoarthritic knee in 1994. She was 135 cm in height and weighed 42.7 kg. The cemented posterior stabilized press-fit condylar (PFC) (Depuy, Warsaw, IN, US) total knee system was used. Patellar resurfacing was performed with a cemented all-polyethylene implant. The femoral component was cobalt-chrome, while the tibial component was titanium alloy. A 12.5-mm thickness of stabilized plus tibial insert was used.

After surgery, her knee had been functioned well for 20 years. One year ago, she had intermittent swelling and effusion of the knee, together with occasional pain. The symptoms had gradually progressed with increasing episodes of giving way. Finally, she felt instability of the knee and decided to come to the hospital. The radiographs showed asymmetrical PE wear with the evidence of loosening of the tibial component (Fig 1). She was diagnosed with aseptic loosening of TKA and consequently underwent revision TKA in 2014. The intraoperative findings included an effusion, hypertrophic synovial tissue and loose fragments of PE. The visible wear was observed at both tibial insert and patellar component. The tibial component was grossly loosened, whereas the femoral and patellar components were well-fixed. Osteolysis was also found in both distal part of the femur and proximal part of the tibia. All components were removed and retrieval analysis of PE tibial insert was performed at the National Metal and Materials Technology Center (MTEC), Thailand.

Retrieval Analysis Results

Wear assessment of the articulating and non-articulating surfaces was performed in 16 zones.⁵ The authors found that PE wear was present in 11 zones without wear on the backsides (Fig 1). In order to detect the changes of color and texture in the damaged areas⁶, the stereomicroscopy was performed, in which the

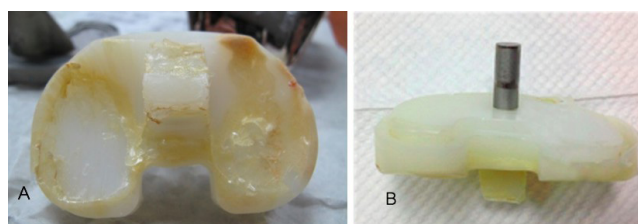


Fig 1. A) Articulating and B) Non-articulating surfaces of retrieved polyethylene tibial insert.

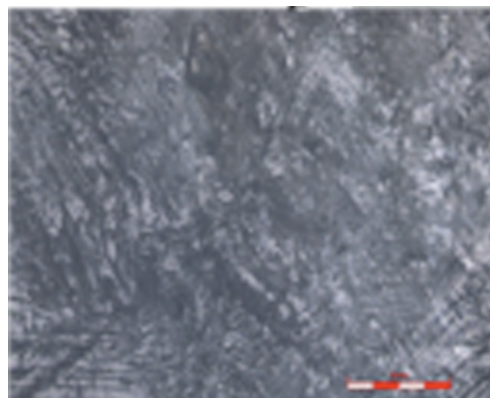


Fig 2. Stereomicroscopy photograph shows scratch and surface damage of polyethylene tibial insert.

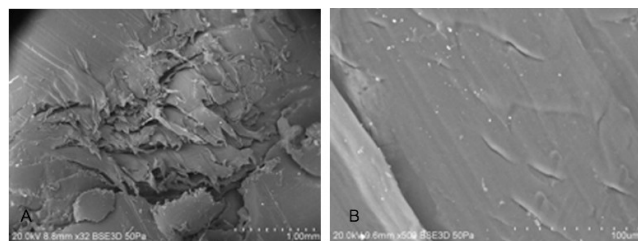


Fig 3. Scanning electron microscopy photographs show delamination (A) and subsurface crack (B) of polyethylene tibial insert.

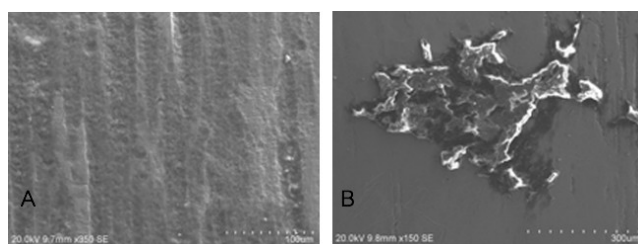


Fig 4. Scanning electron microscopy photographs show surface damage (A) and metal wear debris (B) on metal part of polyethylene tibial.

scratches (Fig 2) and delamination of the PE surface were demonstrated. The specimen was cut and analyzed using a scanning electron microscope (SEM) to observe the insides of PE⁷. Delamination, subsurface cracking and damage were identified in the damaged zones (Fig 3). Furthermore, in the metal part of PE, the surface damage and metal wear debris were also displayed using SEM (Fig 4).

DISCUSSION

This is the first case report in Thailand regarding the retrieval analysis of ultra-high molecular weight polyethylene (UHMWPE) cemented PFC (Depuy, Warsaw, IN, US) in a definite aseptic loosened case after undergoing TKA for 20 years. Our purpose was to find out the mode of failure of PE implant that contributed to wearing of the UHMWPE, which will eventually lead to aseptic loosening after TKA.

From visual inspection, we found that the damages of the UHMWPE component were very severe. Delamination, pitting, burnishing and abrasion, as was shown in figure 1A, were located in all the wear areas consisting of medial articulation, lateral articulation and the post of the UHMWPE.

The UHMWPE tibial components was roughly analyzed by stereomicroscopy to identify the damaged area. We found scratches and surface damage of PE tibial insert, implying that fatigue wear had occurred (Fig 2). Then we examined damaged area using scanning electron microscope (SEM) in order to get the exact details of failure mode. Surface cracks were observed in a wide area and also in various directions. Furthermore, SEM was employed to scan through both articular part (Fig 1A) and non-articular part (Fig 1B) of the UHMWPE. Results showed delamination (Fig 3A) of the medial and lateral articular contact surface and subsurface crack of UHMWPE (Fig 3B), suggesting that adhesive and fatigue wear had occurred. The wear debris was also found on the surface.

The SEM exam of the metal part of PE showed surface crack (Fig 4A) and metal wear debris (Fig 4B) at the metal bar of tibial component on the side of metal part of the UHMWPE. The findings were evidently caused by fretting and abrasive wear mode. This might have happened because of motion between bar of UHMWPE component and the metal component of tibia.

The demonstrated modes of UHMWPE wear, such as abrasive, adhesive, fatigue, fretting and corrosive wear, were similar to many previous reports. Many factors have been reported to have influence on the wear of UHMWPE, for example joint loading, position, motion, degree of bearing conformity and contact stresses through range of motion. Further studies are necessary to evaluate the association between wear mode and these factors.

Summary

This retrieval analysis could demonstrate various modes of wear on UHMWPE. However, we propose that future studies based on the association between

wear of UHMWPE and possible precipitating factors are mandatory.

The retrieval analysis is a very important method for the study of details of failed TKA. Since the number of TKA cases are gradually increasing, preventing its failure is therefore of great importance. The retrieval analysis is a way to prevent such consequences for it could help to improve prosthesis or bearing design and select appropriate material and surgical technique. This primary research could be a great start towards better longevity of TKA and improved quality of life of the patients.

What is already known on this topic?

The retrieval analysis is a very important method for the study of details of failed TKA.

What this study adds?

We propose that future studies based on the association between wear of UHMWPE and possible precipitating factors are mandatory.

What are the implications for public health practice?

Retrieval analysis is now feasible and achievable in Thailand. This method could facilitate further trials to investigate the correlation between mode of failure and other risk factors.

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