INTRODUCTION

In-vivo abrasion of joint replacement bearings has been observed [1] and its effect on polyethylene wear has been previously studied [2–4]. Two methods have been used to simulate this abrasive process in vitro in both hip and knee wear studies. A tumbling abrasion method has been utilized by multiple laboratories and involves the use of a centrifugal polishing machine with various abrasives to abrade the component prior to wear testing [3]. This imparts many low energy impacts of relatively small abrasives onto the surface of the component and results in randomly oriented short scratches. An alternative method that has been previously published utilizes a diamond indenter to controllably create scratches on the surface of the component [5]. The depth, location, orientation, and size of the scratch can be controlled. This study will compare the resulting abrasion damage of these two methods on a modern Cobalt Chromium (CoCr) knee femoral component to the damage found on retrieved components [6].

MATERIALS AND METHODS

A previous study utilized the scratching method to create ‘X’ shaped scratches across the condyles of six femurs [5]. Scratching was performed using a standard Rockwell C indenter with a load of 10N. The angle of the scratches ranged from ±3.5° to ±9.0° based on the rotational kinematics of total knee arthroplasties as described by Mahoney et al [7].

The tumbling abrasion method is similar to that described by previous researchers [3] and utilized a small scale tumbling polishing apparatus (Model #1600; A.E. Aubin Company, Marlborough, CT). The tumbler was filled with 90mL of 500 grit aluminum oxide powder, 200mL of silica embedded plastic media (P6 Plastic Tumbling Media, American Lapidary, Oradell, NJ), and 500mL of deionized water. Three CoCr femoral components were weighted as seen in figure 1 in order to shift the center of mass of the component to the approximate center of rotation of the articulation area which allows for uniform abrasion. Components were abraded for 30 minutes at 40rpm.

Abrasion damage was measured using a NewView 6300 white light interferometer (Zygo, Middlefield, CT) and compared to the retrievals described previously by Weir et al. [5] and Levesque et al. [6].

RESULTS

The CoCr surface was damaged with both abrasion methods. The scratching abrasion resulted in two distinct scratches on each condyle (Fig 3) which are similar to the retrieval in terms of its orientation and magnitude of damage as previously described [3]. The tumbling abrasion method resulted in many overlapping, short, and multi-directional scratches on the surface as seen in Figures 2 and 3C. Scratches were observed in all directions with no preferential orientation. The maximum peak for the scratching method was 3.28µm, and for the tumbling method was 3.02µm.

DISCUSSION AND CONCLUSION

Two different aggressive abrasion methods are compared in this study. The scratching abrasion method creates several distinct surface scratches. This method is highly controllable in terms of scratch depth, position, orientation, and size resulting in an ability to replicate retrieval scratches (Fig 3). However, this method is very time consuming requiring each scratch to be created independently with its own orientation and positioning which does not lend itself well to large variations in scratch parameters.

The tumbling abrasion method is far simpler and creates a wide range of scratch qualities on the entire bearing surface of the component. Surface abrasion consisted of short scratches in all directions. While this method is simpler and creates a wide range of scratches, it has been previously documented that knee femoral scratches tend to be oriented in the anterior/posterior directions [1]. Additionally, the surface quality resulting from the tumbling abrasion appears matte and unlike the retrievals, which tend to have several large distinct A/P oriented scratches as well as some smaller scratches [5].

These methods have yielded significantly different results in terms of wear performance against PE tibial inserts [3,5]. While the tumbling abrasion of femoral knee components has been reported to significantly increase wear rates [3], the scratching method (at various loads and orientations) has shown only a minor increase in wear [5]. While neither method can completely replicate in-vivo scratching, the controllability and the similarity between the scratched femur and the retrieval suggests that this method is more appropriate to simulate abrasive wear of knee replacement devices.

REFERENCES