INTRODUCTION:
Nickel and cobalt present the greatest risk for those suffering hypersensitivity reactions to orthopaedic implants (Gawkrodger 1993, Rooker and Wilkinson 1980). Various strategies have been undertaken: cobalt chrome (CoCr) femoral components can be coated or alternative materials such as ceramics can be used. Titanium niobium nitride (TiNbN) acts as a surface coat to “hide” the CoCr femoral component, therefore affording it an immunoprivileged state (Munro-Ashman and Miller 1976). Compared with CoCr, the metal titanium is soft and hence less scratch resistant. In the 1980s the use of titanium alloy as a bearing surface in the hip and knee led to considerable metallosis and UHMWPE wear; it is now thought unsuitable for use as a femoral component (Nasser et al. 1990, Plitz 2000). Titanium nitride, however, provides a hard countersurface (Goldberg and Gilbert 2004). TiNbN is a coating applied by physical vapour deposition (PVD), a process by which positively charged metal ions are evaporated in a vacuum chamber and react with inert gases introduced to the chamber. The surfaces that are to be coated are negatively charged to allow a strong bond to form between the substrate and the coating (Pappas et al. 1995, Nevelos 2004). TiNbN shows good biocompatibility (Rodriguez et al. 2001, Satomi et al. 1988, Scarano et al. 2003, Khan et al. 1999).

The aim of our study was to determine whether UHMWPE wear generated by TiNbN differed in comparison to CoCr. Our secondary aim was to determine the reason behind any difference in the UHMWPE wear.

METHODS:
Four CoCr Vanguard (Biomet, UK) total knee replacements were used. Three were coated with TiNbN via physical vapour deposition, the other remained uncoated. Four CoCr tibial base-plates were used with 10mm UHMWPE tibial inserts. Two further tibial inserts were used as soak controls. The Stanmore-Instron four station, force driven knee simulator was used, providing six degrees of freedom of motion. The components were fixed using acrylic bone cement to the simulator. Before commencing the test, all the components were aligned. The femoral and tibial components were aligned to 0° of flexion and 0° antero-posterior tilt, varus/valgus and axial rotation respectively. The knee simulator was run at 1 Hz using a standard walking cycle at a temperature of 37°C. The test was run for five million cycles, similar to five years total knee replacement use in vivo.

Prior to commencing testing and after completion of each million cycles standard measurements of surface roughness, weight, surface profiling and lowest points were taken.

RESULTS:
Before testing commenced the average roughness of the TiNbN implants was higher than that of the CoCr implants. The average roughness for CoCr lateral condyle increased over the five million cycles by a factor of 17.41 from 0.017 to 0.296. The corresponding change for the TiNbN coated lateral condyles was from 0.036 to 0.074, equivalent to a rise of a factor of 2.04. The CoCr medial condyle roughness rose from 0.019 to 0.256, a factor of 13.69. The TiNbN coated medial femoral condyle average roughness rose over the course of the test from a start figure of 0.034 to 0.115. This equated to a 3.37 rise. The difference in average roughness was greater for the lateral condyle than the medial condyle (Figure 1).

DISCUSSION:
Surface roughness of TiNbN following simulator testing suggests that it has a greater scratch resistance than CoCr. This was demonstrated on medial and lateral condyles; however, there was a greater difference in average roughness progression for the lateral condyles when compared to the medial. This finding is in accordance with work in and pin on plate and joint simulators (Sawase et al. 2005, Kamali et al. 2005, Peterson et al. 1988).

In spite of the reduction in roughness progression noted for the titanium components, the gravimetric wear was similar to that of the CoCr component tested. The higher friction of the surface of titanium may increase the adhesive wear it induces. Analysis of the surface of the UHMWPE did not reveal any differences between the volumetric wear of UHMWPE of the titanium and CoCr.

Despite a clear reduction in roughness progression over the course of this in vitro test, there was no demonstrable improvement in polyethylene wear measured gravimetrically and by surface profiling. The implant tested may still be of great benefit to patients who are sensitive to nickel and or have a “metal allergy”, but the coat offers no benefit in polyethylene wear. The implant has not been marketed as an alternative to CoCr but an option to patients with metal allergic reactions to ions. Like all prostheses, we await results of the long term clinical follow up of these patients.

Figure 1 TiNbN vs CoCr Average bicondylar roughness

The weight loss of the TiNbN articulating inserts was 0.2111% of the average starting weight, whereas weight loss of the insert articulating against CoCr was 0.1304% of the weight of the tibial insert at the start (Figure 2). The weight of the soaks rose by 0.0372% of their starting weight during the test.

Figure 2 TiNbN vs CoCr weight loss