INTRODUCTION:
Due to increased life expectancy at human population the amount of osteoarthritis of the knee joint will increase. The total knee replacement (TKR) is often the only way to achieve analgesia, to establish the joint function and to correct joint deformation. TKR reached a high grade of quality and safety and has become an often used surgical procedure [1]. TKR most often fail due to aseptic implant loosening. In the absence of infection, aseptic loosening may occur due to the biological response of the bone to stress shielding, micro motion or biological loosening due to osteolysis. It is believed that polyethylene (PE) wear debris, generated at the articulating surfaces, leading to osteolysis and loosening of endoprosthesis [2]. Therefore the prior aim is to minimize the generation of wear debris by providing low-wear bearings. Beside wear caused by adhesion, surface damage and wear can also be caused by three body particles. De Baets et al. showed that 42% of the debris left in situ are bone cement particles which can damage the surfaces and induce wear [3]. The objective of this experimental study was to evaluate the wear of the tibial PE insert of the total knee endoprosthesis system MultiGen Plus CR with metallic and ceramic femoral components at three body wear situation induced by polymethylmethacrylate (PMMA) and zirconia (ZrO2) particles from bone cement. For gait simulations a knee joint wear simulator according to ISO 14243 were used.

Previous experimental studies show less wear of PE/ceramic couplings in comparison to PE/metallic because of the low friction of ceramic surface [4]. Moreover, the incidence of allergic reaction against metallic implant materials increases [5]. Hence, allergic-free implants could improve the long term survival rate of total knee endoprosthesis. Biological inert implants consisting of ceramics could offer an alternative solution to patients with sensitivity to metals [6].

METHODS:
Wear testing was performed for 5 million load cycles using tibial standard PE inserts combined with three cobalt chromium (CoCr) femoral components and three ceramic (BIOLOX® delta) femoral components of MultiGen Plus CR knee system (Lima-LTO S.p.A. Italy). A fourth component of each material is used as load soaked control, to include the liquid absorption of the polyethylene material. Test procedures were carried out on a knee wear simulator from EndoLab GmbH, Rosenheim, Germany according to ISO 14243 (2002).

Bone cement (Palacos R®) was pestled and the size was regulated to ≤30 µm by filtration. The wear test was realized in temperature-controlled test chambers at 37°C containing foetal bovine serum with a protein content of 30g/l. The medium was changed every 500,000 cycles. At every change PMMA particles were added at all stations onto the articulating surface of the tibial PE insert (7mg per condyle). The first 50 cycles of each 500,000 cycles were performed without lubricant to avoid flush away of three body particles by the lubricant. Wear was determined gravimetrically every 500,000 cycles up to 5 million cycles. The surfaces of tibial inserts were analyzed by scanning electron microscope (SEM) after 5,000,000 cycles with and without cleaning process for gravimetrically wear measurement. Furthermore, roughness of the PE insert surfaces and the articulating surfaces of femoral components were analyzed.

RESULTS:
Figure 1 shows the average wear rates of the tibial PE inserts in combination with CoCr and BIOLOX® delta ceramic femoral components. Over 5 million cycles the total wear of polyethylene using the CoCr and ceramic components was 32 ± 4.5 mg and 13 ± 1.9 mg, respectively. The PE/metal and PE/ceramic bearing showed similar wear rates at 500,000 cycles, but at further progress of gait simulation the amount of wear increased rapidly in terms of PE/metal while wear of PE/ceramic revealed a lower increase. SEM pictures of the tibial inserts after 5,000,000 cycles showed bone cement particles at and inside of the articulating surface, as well as polished surfaces with scratches (figure 2). Bone cement particles were not detected after cleaning process for gravimetrically wear measurement, so that three body particles do not influence wear measurement. Analyzes of the surfaces roughness of the PE inserts showed polished regions with deep scratches in parts up to 30 µm caused by bone cement particles, at the articulating area in comparison to the untreated areas at both material pairings. Macroscopic and microscopic analyzes of the articulating surfaces of femoral components showed scratches at the articulating area on the metallic components, caused by bone cement particles, none on ceramics.

DISCUSSION:
Wear debris from PE inserts is the most important reason for osteolysis and revision after TKR [2]. Within different wear mechanisms at artificial knee joints the three body wear is a serious problem [3]. One possibility reducing wear particle release is to use a material for the femoral components with superior friction properties which also show good resistance to three body wear [4]. In the study we could demonstrate that in presence of added bone cement particles the ceramic femoral component led to a wear reduction of 60% at the PE inserts in comparison to the metallic components.

CONCLUSION:
Aim of the present study was to point out the effect of femoral component material in combination with abrasive three body wear particles on the wear properties of TKR. The wear simulator tests demonstrate that the wear of PE inserts under three body abrasion conditions in combination with ceramic femoral components was lower than with metallic femoral components. With regard to reduced wear in presence of three body abrasion particles and anti-allergic properties ceramic is a promising material for femoral components of TKR.

REFERENCES: