INTRODUCTION:

Many types of bioactive bone cement have been developed to overcome the disadvantages of polymethylmethacrylate (PMMA) bone cement, especially its lack of bone-bonding ability, which occasionally leads to aseptic loosening of prostheses used for arthroplasty. Earlier, we showed that bioactive bone cements containing either nano-sized or micron-sized titania (TiO₂) particles had excellent in vivo osteoconductivity. However, anatase phase titania particles contained in these bioactive bone cements raise concerns about their safety in vivo. We developed pure rutile micron-sized titania particles because rutile is the only stable phase, whereas anatase is metastable.

In this study, polymethylmethacrylate (PMMA)-based bone cement containing pure rutile micron-sized titania (TiO₂) particles were developed, and their mechanical properties and osteoconductivity are evaluated.

METHODS:

Spherical titania powder (Ishihara Sangyo Kaisha Ltd, Osaka, Japan) with an average particle size of 3μm and a specific surface area of 2.8m²/g was used as supplied. PMMA powder, synthesized by suspension polymerization with an average molecular weight of 141,000 Da and an average particle size of 34μm was used. SPD-PMMA powder, synthesized by emulsion polymerization and composed of cohered minute particles of PMMA with an average particle size of 0.5μm was added at 13.5 wt% of the PMMA.

The powder was mixed with PMMA powder to give three kinds of TiO₂–dispersed cements, designated T10, T20, and T30 with 10, 20, 30wt% TiO₂, respectively. Commercially available PMMA cement (PMMAc) was used as a control.

Hardened cylindrical cement sample (φ2.5mm*10mm) was inserted manually on rabbit femur vertically. Push out test was performed for evaluation of bonding strength. Animals were reared and the animal experiments were carried out at the Institute of Laboratory Animals, Graduate School of Medicine, Kyoto University, Japan. All procedures were performed according to the Principles of Laboratory Animal Care of the Kyoto University Animal Experiment Committee.

The bending strength, bending modulus, and compressive strength were measured according to the ISO5833 standard.

RESULTS:

Results of this study revealed that polymethylmethacrylate (PMMA)-based bone cement containing pure rutile micron-sized titania particles has outstanding osteoconductivity in vivo, and their mechanical properties were exceeded that of commercially available PMMA cement.

Interfacial shear strength of T10, T20 and T30 were 17.1–24.0MPa each at 12 weeks, and were significantly higher than PMMAc.

The bending strength of T10, T20, and T30 were 86.6 ± 3.7 MPa, 78.7 ± 5.0, and 60.2 ± 8.3, respectively and exceeded significantly that of PMMAc. The compressive strength of T10, T20, and T30 were 129.5 ± 5.1, 130.0 ± 3.3, and 135.0 ± 3.3, respectively and also exceeded significantly that of PMMAc.

DISCUSSION:

In general, the interfacial bonding strength of bone cement depends mainly on its interdigitation with cancellous tissue, which is accomplished by the pressurized injection of the cement in paste form. On the other hand, we inserted the hardened specimens into oversized holes on rabbit femur in this study, because we intended to examine the osteoconductive and bone-bonding potentials of each material. The flexural strength, flexural modulus, and compressive strength were equivalent to or exceeded that of PMMAc.

These results show that bone cement containing pure rutile micron-sized titania particles is a promising material applied to prosthesis fixation.