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Use of porous monoblock patella component should avoid for patient with patella baja

Takao Kaneko*, Norihiko Kono, Yuta Mochizuki, Hiroyasu Ikegami, Yoshiro Musha

Department of Orthopedic Surgery, Toho University School of Medicine, Tokyo, Japan

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ABSTRACT

Background: Although many studies have evaluated the success of porous tantalum component in primary and revision cementless total knee arthroplasty (TKA) cases, few studies have reported the breakage of porous tantalum monoblock patella component (PTMP). The purpose of this study was to investigate the radiographic outcomes of breakage of PTMP at short-term follow up.

Methods: This was a retrospective study of 49 consecutive knees in 43 patients who underwent TKA surgery between September 2012 and March 2014. Bone marrow contents/tissue volumes (BMC/TV. mg/cm^3) were evaluated using 2-dimensional osteomorphometry software with 2D- multi-detector-row computed tomography (2D-MDCT) to measure fixation of the bone-prosthesis interface with patella at 6, 12, and 24 months after surgery. Clinical follow up was obtained by reviewing each patient at orthopedic record.

Results: We experienced a case that resulted in breakage of PTMP without traumatic episode at 26 months after surgery. Relative changes of Bone Mineral Contents per Tissue Volume. (BMC/TV mg/cm^3) at ROI. 1 (superior border of the patella) and ROI. 2 (peg of patella) were significantly higher than ROI.3 (inferior border of patella) at 6, 12 and 24 months after surgery ($p < 0.001$. $p < 0.01$). Patient with breakage of PTMP has patella baja (Insall- Salvati ratio: 0.72), and the relative change of BMC/TV at ROI.1 and 2 for patients who experienced a breakage of PTMP was higher than any other patients.

Conclusion: The present study revealed that the use of PTMP should be avoided for patients with patella baja.

1. Background

Patellofemoral complications continue to be among the most prevalent causes of unsatisfactory results following total knee arthroplasty (TKA)[1,2]. These account for almost 50% of re-operations for various reasons such as anterior pain, maltracking, component wear, fracture, and loosening[1–8]. Prosthetic fixation and failures, including component migration and prosthetic fracture are related to bone mineral density. Bone mineral density continues to decrease 5% per year, for as long as 2 years after TKA[9–16]. Stress shieldings are observed under circumstances that the prosthesis of 30 MPa or more of the modulus of elasticity becomes rigidly fixed. Trabecular metal, the material utilized in our study, is characterized to have 1/5 (3–4 Gpa) of the modulus of elasticity that cortical bone has; therefore, stress shieldings are not likely to occur. Followed by the theory "Bone adapts its morphology (density/microarchitecture) in response to the local loading conditions in such a way that a uniform tissue loading is achieved" described by Wolff[17], the changes in bone quality parameters of trabecular patterns under Porous tantalum monoblock patella component (PTMP) were assessed. Noyama et al.[18] reported that an oriented groove structure for controlling stress distribution was introduced to the proximal medial region of the femoral stem.

There are many dynamic analyses about load distribution after TKA. Computer simulations such as Knee SIM simulates various lower extremity movements such as gait, deep flexion, stepping up and down the stairs, and squats. Also, it is capable of measuring intra-articular kinetics, intra-articular stress, and muscle strength/ligament tension necessary to achieve these series of movement, while users can maneuver parameters to make comparisons of implant locations, ligament location, degree of tension, etc. under the controlled condition. Therefore, with all the reasons above, computer simulation is effective for the discussion of surgical technique. In addition, the contact stress

Abbreviations: TKA, total knee arthroplasty; PTMP, porous tantalum monoblock patella; 2D-MDCT, two-dimensional multi-detector-row computed tomography; BMC/TV, bone mineral contents per tissue volume; BMI, body mass index; UHMWPE, ultra high molecular weight polyethylene); AP, anteroposterior; ROI, regions of interest; CT, computed tomography; BMD, bone mineral density; BV, bone volume; TV, total volume

* Corresponding author at: Department of Orthopedic Surgery, Toho University School of Medicine, 2-17-6 Ohashi, Meguro-ku, Tokyo153-8515, Japan.
E-mail addresses: takao-knee@oha.toho-u.ac.jp (T. Kaneko), banzai.nippon@hotmail.co.jp (N. Kono), yuta.mochizuki@med.toho-u.ac.jp (Y. Mochizuki), hiroyasu.ikegami@med.toho-u.ac.jp (H. Ikegami), musha@oha.toho-u.ac.jp (Y. Musha).

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between polyethylene and patella can be understood using Finite Element Analysis (FEA) together with computer simulation[19–24]: However, we need to be careful on the interpretation of computer simulation for the dynamic analysis of knee kinematics because this is an analysis “in the computer”.

Recently, intraoperative measurement of tibiofemoral forces using sensor-integrated tibial tray has been taken[25–28]; however, subjects in these studies were under anesthesia when manual stress were applied.

PTMP has been introduced as metallic implant material for cementless TKA and increased initial stability and accelerated bone ingrowth[29]. Thus, PTMP was expected to facilitate the increase in bone mineral density in the bone-prosthesis interface with patella after TKA; however, we experienced a case that resulted in breakage of PTMP without traumatic episode.

To our knowledge, there are no published studies about the breakage of PTMP between the bone internal structure due to load distribution under PTMP using two-dimensional multi-detector-row computed tomography (2D-MDCT). For post-operative TKA patients, our static analyses utilized 2D-MDCT to periodically measure BMC/TV (Bone Mineral Contents per Tissue Volume. mg/cm^3) at right underneath PTMP in accordance with component alignment. We measured bone quality (BMC/TV) instead of BMD with useful clinical parameter.

The aim of this study was to investigate the origin of the breakage of PTMP and the bone internal structure around patella component at 6.12 and 24 months after the operation.

2. Methods

2.1. Study design

This was a retrospective study of 49 consecutive knees in 43 patients (20 knees in 18 men, 29 knees in 25 female) who underwent TKA surgery at our institution between September 2012 and March 2014. The mean age at the time of surgery was 79.5 years (range: 55–89 years). The mean body mass index (BMI) was 24.6 (range: 18.2–27.9). All surgeries in this study were performed using PTMP (trabecular metal; Zimmer Inc.Warsaw, Indiana). PTMP has a single fixation lug (interference fit and hexagonal peg) with direct compression molding of UHMWPE (Ultra High Molecular Weight polyethylene) and ease of revision (Fig. 1). Subjects in the present study were approved by the Institutional Review Board of our hospital, and they were informed on the risk of radiation exposure required to implement this study. Inclusion criteria were pre-operative medial osteoarthritis of the knee. Exclusion criteria were preoperative rheumatoid arthritis, lateral knee osteoarthritis, patients with the history of patella dislocation, knee synthesis and/or high tibia osteotomy.

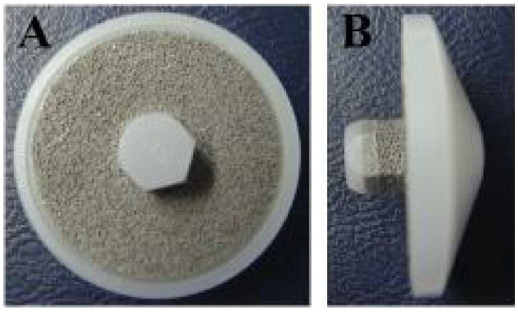

Fig. 1. Photograph of the cementless porous tantalum monoblock patella component (PTMP: Trabecular Metal; Zimmer Inc.Warsaw, Indiana). Note a single fixation lug (interference fit and hexagonal peg) with direct compression molding of Ultra High Molecular Weight polyethylene. The Advantages are easier revision surgery (A: patella joint facet site. B: lateral view).

2.2. Surgical techniques

In all cases, the TKA surgical procedure was performed by one surgeon (T.K) and was minimally invasive surgery; with a skin incision of 8–11 cm. At first, the distal femoral cutting guide block was aligned using an intra-medullary guide, and the proximal tibia cutting block was aligned using an extramedullary guide. For the femur and tibia, a standard 6° valgus angle guide and 7° posterior inclination guide were used for all patients. The rotational alignment was adjusted to the surgical epi-condylar axis for the femoral component, and medial one third of tibia tuberosity at the level of patellar-tendon attachment for the tibia component. We confirmed the tension and appearance of posterior cruciate ligament. The femoral components were cemented and the tibial components were fixed with cementless porous tantalum modular components and patella components were fixed with cementless PTMP with onlay fixation. All the patients followed the same post-operative rehabilitation protocol.

2.3. Outcome measures

The Knee Society Score (KSS)[30] and Hospital for Special Surgery patella score[31] were measured by one author (N.K) who was not involved with any of the surgical procedure. The standard standing anteroposterior (AP), lateral, and skyline patellar radiographs were measured for pre- operative and twenty-four months after the operation. Knees were fully extended and located so that the patella was centered between the femoral condyles and facing forward. The Insal-Salvati ratio and posterior condylar offset/patella length ratio were measured on the lateral radiograph. The patellar tilting angle and congruence angle and displacement of patella were measured by drawing a line on the anterior aspect of the femoral condyle and another line along the posterior aspect of the articular surface of the patella[32]. We took MDCT with Phantom (Taisho-Toyama Pharm. Co, Ltd, Tokyo. Japan) consisting of a cylindrical material that reproduces the bone density of cortical bone on the outer surface, and that of cancellous bone internally to determine the bone volumes at 6, 12, 24 months postoperatively (Fig. 2). From the obtained images, the cancellous trabecular structure was visualized three-dimensionally with 2D-osteomorphometry software (TRI/2D-BON64; RATOC System Engineering Co., Ltd. Tokyo, Japan), and the structural parameters were calculated. The structural parameters targeted for this analysis were those recommended by the American Society for Bone and Mineral Research: Bone Mineral Contents/Tissue Volume (BMC/TV.mg/cm^3) values, representing quantification of bone formation in total volumes, representing mineralized bone volume as a percentage of total volume. In

Fig. 2. We took MDCT with Phantom (Taisho-Toyama Pharm. Co, Ltd, Tokyo. Japan) consisting of a cylinder composed of a material corresponding to cortical bone and filled with a material having a bone density corresponding to cancellous bone for determination of the bone volumes at postoperatively at 6.12 and 24 months after surgery.