Survivorship comparison of all-polyethylene and metal-backed tibial components in cruciate-substituting total knee arthroplasty—Chinese experience

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Abstract Considering its cost saving, the all-polyethylene tibial component is of potential interest in developing countries like China. But to our knowledge, a survivorship comparison of all-polyethylene and metal-backed tibial components in posterior cruciate ligament-substituting total knee arthroplasty (PS-TKA) has not been studied in China previously. Using survivorship analysis, we have studied the midterm outcome of 34 cemented PS-TKA using an all-polyethylene tibial component and of 34 cemented PS-TKA using a metal-backed tibial component which has an identical articular surface with all-polyethylene tibial components. All operations were performed by the same group of surgeons; 58 patients underwent a unilateral operation and five patients a bilateral operation. These patients had a mean follow-up of 5.9 years (range: 5–7 years); three patients were lost to follow-up and one was revised for infection. No significant difference between the two groups was reported regarding HSS scores, ROM, clinical and radiographic parameters measured and survival rates. Although the Asian lifestyle includes more squatting and bending of the knee, the results of this series of TKA using all-polyethylene tibial components in Chinese people are comparable to the satisfactory results of other reported all-polyethylene series whose patients are mainly Western people. Considering its cost saving and excellent clinical result, the all-polyethylene tibial component is of potential interest in developing countries.

Résumé Les plateaux tibiaux tout polyéthylène APTC permettent une économie financière aux niveaux des implants et ont un intérêt potentiel pour la Chine. En utilisant une analyse avec courbe de survie, nous avons réalisé un suivi moyen de 5,9 ans (5 à 7 ans) pour 34 prothèses postéro stabilisées cimentées PS-TKA en utilisant un plateau tout polyéthylène APTC. Et 34 prothèses avec un métal back MBTC avec la même surface de glissement que l'APTC. Il n'y a pas de différence significative entre les deux groupes si l'on considère le score HSS, la mobilité et la clinique ainsi que les paramètres radiographiques et les courbes de survie. Les courbes de survie à 5,9 ans sont de 93,55% pour le groupe APTC et de 93,75% pour le groupe MBTC. Cependant, le mode de vie asiatique nécessitant des flexions antérieures et une flexion importante des genoux ont un résultat identique chez les chinois (en utilisant une APTC) avec des résultats comparables et tout à fait satisfaisants comparées aux autres séries de plateaux tout PE des populations occidentales. Si l'on considère l'économie réalisée et les excellents résultats cliniques des prothèses APTC avec un composant tout polyéthylène, ceux-ci sont intéressants pour ces pays en voie de développement.

Introduction

The design of all-polyethylene tibial components preceded monoblock or modular metal-backed tibial components by several years. Previous studies that have directly compared all-polyethylene and metal-backed tibial components generally have failed to show any differences in terms of outcome and prosthesis survival [1, 14, 18]. Norgren et al. [15] reported the quality of the fixation of the tibial component in 21 patients (23 knees) which was a prospective inves-

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tigation using radiostereometric analysis. The results showed no negative consequences as regards fixation using all-polyethylene tibial components. In all aspects, the all-polyethylene components displayed magnitudes of migration on a par with, or sometimes even lower than, their metal-backed counterparts.

Considering its cost saving, the all-polyethylene tibial component is of potential interest in developing countries like China. But to our knowledge, a survivorship comparison of all-polyethylene and metal-backed tibial components in posterior cruciate ligament-substituting (PS) total knee arthroplasty (TKA) has not been studied in China previously. The aim of this study was to compare the results of Chinese patients in a retrospective randomised fashion between the same brand of cemented PS TKA, one group with an all-polyethylene tibial component and the other group with a metal-backed tibial component, with a minimum five-year follow-up. Because the Asian lifestyle includes more squatting and bending of the knee, we also wondered whether the midterm results of TKA using an all-polyethylene tibial component in Chinese people would be affected by this lifestyle.

Materials and methods

Approval was obtained from the Institutional Review Board of West China Hospital of Sichuan University prior to performing the study. Between 2000 and 2002, 31 patients underwent 34 cemented PS TKA using an all-polyethylene tibial component (Press Fit Condylar, J & J/DePuy, Warsaw, IN, USA). Among them, there were 12 men and 19 women, the mean age at operation was 62.03 ± 6.04 years (range: 48–72 years) and the mean weight was 64.00 ± 5.36 kg (range: 55–75 kg). The preoperative Hospital for Special Surgery (HSS) score was 39.03 ± 1.97 (range: 36–42). The underlying diagnoses were listed as follows: degenerative osteoarthritis in 20 patients (64.52%), rheumatoid arthritis in nine patients (29.03%) and traumatic arthritis in two patients (6.45%); 28 patients underwent a unilateral operation and three patients a bilateral operation.

To match the all-poly group, 32 patients underwent 34 cemented total knee arthroplasties using a metal-backed tibial component (Press Fit Condylar, J & J/DePuy, Warsaw, IN, USA) which has an identical articular surface to all-polyethylene tibial components during the same period. Among them, there were 14 men and 18 women, the mean age at operation was 60.38 ± 5.41 years (range: 50–68 years) and the mean weight was 64.44 ± 6.22 kg (range: 51–73 kg). The preoperative HSS score was 39.28 ± 2.20 (range: 34–42). The underlying diagnoses were listed as follows: degenerative osteoarthritis in 25 patients (78.13%) and rheumatoid arthritis in seven patients

(21.87%); 30 patients underwent a unilateral operation and two patients a bilateral operation.

All patients of the two groups had to satisfy the following criteria: 50 years or older with definite diagnosis of non-infected arthritis; the pain or dysfunction of the knee was severe enough to disable normal work and life; conservative treatment had been ineffective; and having TKAs not necessitating bone grafting, modular stems or augments, or more constrained designs. If the patient did not have medical insurance, he/she would be enrolled in the all-polyethylene tibial component group, otherwise be enrolled in the metal-backed tibial component group. The patients were not randomised, but both components were purposefully used so that a comparative review such as this could be performed. The patient groups were matched for age, gender, body weight and preoperative HSS score.

All patients of the two groups received identical cemented femoral components and cemented all-polyethylene patellar implants. Based on the numbers available, there were no statistically significant differences between the demographic data of the two groups (Table 1).

All operations were performed by the same group of surgeons in laminar flow operating rooms. Standard operative techniques were used: midline skin incision and medial parapatellar approach, intramedullary alignment for the femoral component with 3° of external rotation relative to the transepicondylar axis and extramedullary alignment for the tibial component. The thicknesses of the all-polyethylene tibial components were listed as follows: 10 mm in 14 knees, 12.5 mm in 17 knees and 15 mm in three knees. The thicknesses of the polyethylene insert in the metal-backed tibial group were listed as follows: 10 mm in 23 knees and 12.5 mm in 11 knees. The posterior cruciate ligaments (PCL) were all substituted and patellar replacements were carried out in all patients. Perioperative antibiotic prophylaxis, thrombosis prophylaxis and all details of the postoperative therapy routine were identical in the two groups.

The HSS score and range of motion (ROM) testing were used to assess the clinical outcomes. Weight-bearing anteroposterior and lateral radiographs were obtained and

Table 1 Demographic data of the patients

Group	AP	MB	<i>p</i> value
Age (years)	62.03 ± 6.04	60.38 ± 5.41	0.26
Gender (M/F)	12/19	14/18	0.69
Body weight (kg)	64.00 ± 5.36	64.44 ± 6.22	0.77
Preoperative HSS score	39.03 ± 1.97	39.28 ± 2.20	0.64

AP all-polyethylene tibial components, MB metal-backed tibial components

evaluated for mechanical alignment and radiolucent lines according to the Knee Society guidelines. Revision was used as the endpoint and survival analysis was performed.

The statistical analysis was performed using the statistical computer software SPSS 10.0. The unpaired Student's *t*-test was used for parametric data, and the Mann-Whitney U test was used for non-parametric data. Fisher's exact test was used for comparison of discrete variables between the two groups. The life table method was used to compare the survival rate. The level of significance was set at $p < 0.05$.

Results

To date, three patients (three knees) have lost contact, including two in the all-polyethylene tibial group and one in the metal-backed tibial group. So the rate of follow-up was 95.242%. Ten patients (ten knees) who were unable to attend follow-up because they had moved house were contacted by telephone and letter. Apart from one revised patient, all the other 59 patients (64 knees) who were reviewed were satisfied with their new joints and had not undergone further knee surgery.

Clinical results

At review, the mean follow-up of all the patients was 5.9 years (range: 5–7 years). The knee function, as documented by HSS score and ROM examination for all total knee arthroplasties, is shown in Table 2. Although postoperative improvement in HSS score was significant ($p < 0.05$), these scores did not differ significantly between the all-polyethylene tibial and metal-backed tibial groups. Similarly, the postoperative ROM did not show a significant difference between the two groups ($p > 0.05$). One metal-backed tibial component was revised at 14 months for proven *Staphylococcus aureus* infection; two-stage revision was performed within six months and the final HSS score was 78. As of the latest follow-up, there was no case of aseptic implant loosening among the two groups.

Table 2 Clinical function of total knee arthroplasty

Group	AP	MB	<i>p</i> value
Preoperative HSS score	39.03±1.97	39.28±2.20	0.64
Postoperative HSS score	85.48±1.88	85.57±1.79	0.86
Preoperative ROM	109.52±9.25	110.78±8.90	0.58
Postoperative ROM	102.24±7.51	102.67±8.27	0.84

AP all-polyethylene tibial components, MB metal-backed tibial components

Table 3 Radiographic comparison of postoperative alignment and tibial component position

Group	AP	MB	<i>p</i> value
Axial alignment (° valgus)	5.93±0.84	5.87±0.77	0.76
Tibial coronal position (° varus)	1.90±1.18	1.77±1.17	0.67
Tibial sagittal position (° slope)	6.35±1.37	5.60±1.71	0.07

AP all-polyethylene tibial components, MB metal-backed tibial components

Radiological results

During radiological assessment, no sign of subsidence of the tibial components was found. Evidence of radiolucent lines was revealed in four (12.5%) tibial components for the all-polyethylene tibial group and three (9.38%) tibial components for the metal-backed tibial group ($p > 0.05$, no significant difference), including five cases of rheumatoid arthritis and two cases of degenerative arthritis. The distribution of the radiolucent lines in the anteroposterior view was mainly in zone 1 (six knees) and fewer in zone 4 (one knee); the mean width of the radiolucent lines was less than 2 mm. The presence of a radiolucent line seemed to have no relation with the HSS scores and none of these seven knees was symptomatic. No radiolucencies were observed at the femoral or patellar parts.

A comparison of postoperative axial alignment and tibial component position between the all-polyethylene tibial and metal-backed tibial groups is shown in Table 3. Similarly, the femoral-tibial angle, the tibial cutting surface angle and the tibial posterior slope angle did not differ significantly ($p > 0.05$).

Survival analysis

Survival analysis was performed by the life table method. If all three cases lost to follow-up are assumed to have failed, the five-year cumulative survival rates (95% confidence interval) were 93.55% (84.95–100%) for the all-polyethylene tibial group and 93.75% (85.35–100%) for the metal-backed tibial group ($p = 0.96$).

Discussion

The original design of TKA used an all-polyethylene tibial component. Because of the poor design of the all-polyethylene component and the poor quality of the old polyethylene material at that time, the reported survival rate of this kind of prosthesis can be as low as 68.11% at around ten years [5, 18]. Most designs have since used metal-backed tibial components in TKA in order to improve the

load distribution and increase survivorship [2, 3]. However, this idea is still undergoing scrutiny.

The metal-backed tibial component in TKA is characterised by the following advantages: the polyethylene insert may be changed without removing the tibial component in some revision cases and the excellent primary bone-prosthesis contact interface can be acquired with different modular augmentation or stem components in bone-deficient patients. But these merits do not relate with the follow-up survivorship significantly. The claimed advantage of better load distribution is based primarily on *in vitro* biomechanical studies [2, 3] and has still not been confirmed *in vivo*. To our knowledge, there have been no prospective randomised studies proving superiority of the metal-backed implants over the all-polyethylene tibial components since the 1990s [1, 14, 15, 18].

Besides, the metal-backed tibial component has its inherent flaws. Since the level of the joint line should not be elevated or lowered during operation, the addition of the metal back requires more proximal tibial resection for the same polyethylene thickness or selection of a thinner polyethylene insert. If more proximal tibial bone were resected, the strong supportive bone in the proximal tibia would be lost and the loosening rate of the tibial prosthesis would increase potentially. On the other hand if a thin polyethylene insert were chosen, the plastic wear would be accelerated [22, 26]. The polyethylene insert is likely to dislocate from the metal-backed tray, although this is a rare complication. Indeed, metal-backed tibial components are significantly more expensive than the all-polyethylene tibial components, and this expense may be difficult to justify without a better survivorship.

Upon the development of reconstructive joint arthroplasty and advances in materials technology, together with the recognition of the flaws of metal-backed tibial components, the appropriately designed all-polyethylene tibial components have attracted the attention of orthopaedic surgeons once again. This modified polyethylene tibial component provides not only more congruent articulation [7, 8], but also excellent wear-resistant, oxidation-resistant and pressing-resistant capacity [12, 13]. An *in vitro* study showed that the load distribution on the proximal tibia is similar between the all-polyethylene tibial components group and the metal-backed tibial components group provided the thickness of the all-polyethylene tibial components is ≥ 10 mm. Therefore, the all-polyethylene tibial components whose thickness is ≥ 10 mm should be chosen during TKA. If the all-polyethylene tibial component is too thick to maintain the normal level of the joint line, however, it will affect the recovery of knee kinematics adversely after operation. This applies particularly in cruciate-retaining TKA [23].

The surgical techniques of TKA using an all-polyethylene tibial component are similar to the routine operation. Since the thickness of the tibial component cannot be adjusted after cement fixation, the tibial trial should be used to examine the stability and activity of the knee joint repeatedly before final prosthesis insertion. It must be kept in mind that the size of the all-polyethylene tibial component should satisfy the requirements of stability and activity simultaneously. During the process of tibial prosthesis insertion, the all-polyethylene component should be pressed to the proximal tibia by hand as much as possible so that hammer strike which is harmful to the mechanical property of polyethylene can be minimised. In order to remove the undetectable polyethylene debris produced during the operation, the wound cavity should be irrigated repeatedly with abundant antibiotic saline solution before closure.

In this study, the radiolucent lines surrounding tibial components appeared mainly in rheumatoid cases (71.4%), which may be related to the poor bone quality and subsequent osteolysis which is induced by wear debris [4]. Ritter and Scuderi et al. reported that non-progressive radiolucencies of 2 mm or less seem to have little clinical significance [20, 24], which corresponds to our study in which the presence of radiolucent lines had no relation with the HSS scores and none of these seven knees was symptomatic. Although the presence of a radiolucent line around the stem did not affect HSS scores, we still presume that this sign may be an early indicator of potential late failure.

Patellar resurfacing in TKA remains a topic of debate because of the potential complications, including patellar fracture, patellar instability, implant loosening, component breakage and rupture of the extensor mechanism [11, 19]. The suggested indications for patellar resurfacing include inflammatory arthritis and significant Outerbridge grade III or grade IV patellofemoral arthritis, especially when associated with patellar subluxation or dislocation [6, 25]. In China, most of the patients received TKA procedures in the late stage of osteoarthritis or rheumatoid arthritis which usually involve the patellofemoral joint, so patella resurfacing is more common. In this study, all patients received identical cemented all-polyethylene patellar implants.

In this study, we compared the midterm results of all-polyethylene tibial components and metal-backed tibial components in TKA. No significant difference between the two groups was found regarding HSS scores, ROM, clinical and radiographic parameters measured and survival rate. Although the Asian lifestyle includes more squatting and bending of the knee, the results of this series of TKA using all-polyethylene tibial components in Chinese people are comparable to the satisfactory results of other reported all-polyethylene and metal-backed series whose patients are mainly Western people [9, 10, 16, 17, 21]. Therefore, with the right patient and skilled operative technique, the all-

polyethylene tibial component is a cost-effective alternative to metal backing in groups of patients with relatively low physical demands.

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