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Original article

Comparison of mode of failure between primary and revision total knee arthroplasties

H. Liang , J.K. Bae , C.H. Park , K.I. Kim , D.K. Bae , S.J. Song *

Department of orthopaedic surgery, college of Medicine, Kyung Hee university, 26, Kyunghee-daero, Dongdaemun-gu, Seoul 130-701, Republic of Korea

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ABSTRACT

Introduction: Cognizance of common reasons for failure in primary and revision TKA, together with their time course, facilitates prevention. However, there have been few reports specifically comparing modes of failure for primary vs. revision TKA using a single prosthesis. The goal of the study was to compare the survival rates, modes of failure, and time periods associated with each mode of failure, of primary vs. revision TKA.
Hypothesis: The survival rates, modes of failure, time period for each mode of failure, and risk factors would differ between primary and revision TKA.
Material and methods: Data from a consecutive cohort comprising 1606 knees (1174 patients) of primary TKA patients, and 258 knees (224 patients) of revision TKA patients, in all of whom surgery involved a P.F.C® prosthesis (Depuy, Johnson & Johnson, Warsaw, IN), was retrospectively reviewed. The mean follow-up periods of primary and revision TKAs were 9.2 and 9.8 years, respectively.
Results: The average 10- and 15-year survival rates for primary TKA were 96.7% (CI 95%, ± 0.7%) and 85.4% (CI 95%, ± 2.0%), and for revision TKA 91.4% (CI 95%, ± 2.5%) and 80.5% (CI 95%, ± 4.5%). Common modes of failure included polyethylene wear, loosening, and infection. The most common mode of failure was polyethylene wear in primary TKA, and infection in revision TKA. The mean periods (i.e., latencies) of polyethylene wear and loosening did not differ between primary and revision TKAs, but the mean period of infection was significantly longer for revision TKA (1.2 vs. 4.8 years, $P = 0.003$).
Discussion: Survival rates decreased with time, particularly more than 10 years post-surgery, for both primary and revision TKAs. Continuous efforts are required to prevent and detect the various modes of failure during long-term follow-up. Greater attention is necessary to detect late infection-induced failure following revision TKA.
Level of evidence: Case-control study, Level III.

1. Introduction

The cognizance of long-term survival rates, common reasons for failure, and their onset latencies, is important in both primary and revision total knee arthroplasty (TKA) [1–3]. Survival rates may be relatively poor in revision TKA, compared with primary TKA, due to increased age and comorbidities, poor soft tissue condition and bone quality from repeated surgeries, and the increased likelihood of constrained prosthesis use [1,4]. Modes of failure following primary and revision TKAs include wearing of the polyethylene or loosening of the components, in addition to infection, instability, and periprosthetic fracture [5–7].

Previous studies have reported various failure frequency rates, in individual primary or revision TKA, attributable to these different causes [1,5,6,8–15]. We suggest that comparison of modes of failure, for every instance of primary vs. revision TKA which involved a single prosthesis design during the same follow-up period, would provide more reliable information by reducing selection bias. In addition, the mean latency of onset, or period, for each mode of failure may also differ. If surgeons possess detailed information pertaining to the time period for each mode of failure, they will be able to manage patients and detect failures more effectively. An in-depth understanding of the risk factors associated with each mode of failure should facilitate risk-benefit analysis for individual TKA or revision TKA patients.

The purpose of the present study was to compare the survival rate, mode of failure, and period of each mode of failure, of primary vs. revision TKA. A second objective was to evaluate the risk factors

* Corresponding author.
E-mail address: songsjun@khmc.or.kr (S.J. Song).

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associated with each mode of failure. We hypothesized that survival rates, modes of failure, period for each mode of failure, and risk factors would differ between primary and revision TKA.

2. Methods

Between 1990 and 2012, 1606 primary TKAs (1174 patients) and 258 revision TKAs (224 patients) involving use of a single prosthesis design (P.F.C.®/Press Fit Condylar; Depuy, Johnson & Johnson, Warsaw, IN) were retrospectively reviewed. The majority of revision TKAs were performed using the P.F.C.®, which was the one of the most commonly used prosthesis for the primary TKA in our hospital. That's the reason why we choose the primary and revision TKA using P.F.C.® to compare the mode of failure after index arthroplasty.

During the study period, 2311 primary TKAs were performed using other prostheses and 38 primary TKA were performed using the constrained condylar knee (CCK) insert of P.F.C.® prosthesis. Two revision TKAs were performed using other posterior stabilized prostheses, 18 revision TKAs were performed using the CCK insert of P.F.C.® prosthesis, and seven revision TKAs were performed using a rotating hinge prostheses. All these cases were excluded in the present study.

The study was approved by the Institutional Review Board (KHUHMDIRB 1111-02). The average age was 64.5 years in primary TKA and 66.1 years in revision TKA ($P = 0.026$) (Table 1). The posterior stabilized prosthesis was used in 83.6% of primary TKA, and in all revision TKA ($P < 0.001$) (Table 1). The polyethylene insert with γ-radiation in air for the sterilization were less frequently used in primary TKA than in revision TKA (24.1% vs 30.6%, $P = 0.130$). There were no significant group differences in demographic characteristics, except age and use of posterior stabilized prosthesis (Table 1). The mean follow-up periods, for the primary and revision TKA groups, were 9.2 (range: 2.0–23.7 years) and 9.8 (range: 2.0–21.7 years) years, respectively.

2.1. Survivorship analysis

Five-, ten-, and fifteen-year survival rates were analyzed using the life table and Kaplan-Meier methods. Survival rates were compared, between the primary and revision TKA groups, using the Mantel-Cox log rank test. Patients who did not visit our outpatient clinic during the previous two years were followed up by telephone or mail, using a standardized questionnaire to determine whether the implants were retained, and when they were revised at other hospitals. Two hundred and forty-one TKA patients, and 37 revision TKA patients, were evaluated by telephone or mail although all the other patients were regularly follow-up in outpatient clinic.

The unit for the follow-up interval was 1 year; annual success was defined as the implant remaining in place throughout the unit time period. The primary end point was the total time between the initial operation and the revision or re-revision TKA, or removal of the implant for any reason. Patients who had died from causes unrelated to TKA, or were not followed up, were categorized as censored. The length of the follow-up period was determined by date of death or the day of the final follow-up visit. Statistical analysis was performed using the SPSS software (ver. 18, SPSS Inc., Chicago, IL); a P-value of < 0.05 was considered to indicate significance.

2.2. Mode of failure

Modes of failure in primary and revision TKA were classified according to general method employed [16,17], and categorized as either polyethylene wear, loosening, infection, instability, periprosthetic fracture or other. They were determined by reviewing the chart, in addition to laboratory test, joint fluid analysis, radiograph, and intraoperative findings. When multiple modes of failure were noted, the senior surgeon determined the predominant mode. Overall prevalence rates for each mode of failure were compared for primary vs. revision TKA (Chi-square test).

2.3. Period of modes of failure

The periods of each mode of failure were defined as the interval between index arthroplasty and revision or re-revision of TKA, and were compared between the primary and revision TKA groups (Student's t-test). The survival rates were also compared between two groups according to the each mode of failure (Mantel-Cox log rank test).

2.4. Risk factors for the individual modes of failure

Age, gender, diagnosis, and sterilization method for the polyethylene insert, were analyzed using multivariable regression analysis to determine the risk factors for overall and individual modes of failure (Cox proportional hazard model). Age categories were 65 years or less, and greater than 65 years, at the time of surgery. Contribution of diagnosis to the modes of failure included only osteoarthritis and rheumatoid arthritis (RA). The sterilization method applied to the polyethylene insert was categorized as either γ-radiation in air, or γ-radiation in a vacuum.

2.5. Surgical technique

All primary TKAs were carried with consistent surgical principles. The bone cuts were mad using prosthesis specific instruments with a measured resection and a carefully planned soft-tissue technique. All patellae were resurfaced. All implants were cemented using Simplex P® (Howmedica, Mahwah, USA). Cefazonline (1 g) was added per each pack of the cement (40 g). The basic principle of revision TKA was not different from the primary TKA's in

Table 1
Demographics of primary and revision TKA.

	Primary TKA	Revision TKA	P-value
Number of patients	1174	224	
Number of knees	1606	258	
Age (year)	64.5 ± 9.2 (23–85)	66.1 ± 9.8 (31–86)	0.026
≥ 65/ < 65 (%)	648/526 (55.2/44.8)	129/95 (57.6/42.4)	0.252
BMI (kg/m^2)	26.2 ± 2.8	27.0 ± 2.6	0.237
Gender (female/male) (%)	1080/94 (92.0/8.0)	205/19 (91.5/8.5)	0.438
Right/Left (%)	836/770 (52.1/47.9)	129/129 (50/50)	0.546
OA/RA/2° OA/others (%)	1379/153/53/21 (85.9/9.5/3.3/1.3)	193/27/16/22 (74.8/10.5/6.2/8.5)	0.064
PCL retaining/substituting (%)	264/1342 (16.4/83.6)	0/258 (0/100)	< 0.001
Sterilization (r-vac/r-air) (%)	1219/387 (75.9/24.1)	179/79 (69.4/30.6)	0.130
Follow-up periods (year)	9.2 ± 5.1 (2.0–23.7)	9.8 ± 4.5 (2.0–21.7)	0.073

BMI: body mass index; 2° OA: post-infectious or post-traumatic osteoarthritis; r-vac: r-radiation in vacuum; r-air, r-radiation in air.