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SYMPOSIUM: SPECIAL CONSIDERATIONS FOR TKA IN ASIAN PATIENTS

What Are the Causes of Revision Total Knee Arthroplasty in Japan?

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Abstract

Background There is limited information regarding the cause of revision TKA in Asia, especially Japan. Owing to differences in patient backgrounds and lifestyles, the modes of TKA failures in Asia may differ from those in Western countries.

Questions/purposes We therefore determined (1) causes of revision TKA in a cohort of Japanese patients with revision TKA and (2) whether patient demographic features and underlying diagnosis of primary TKA are associated with the causes of revision TKA.

Methods We assessed all revision TKA procedures performed at five major centers in Hokkaido from 2006 to 2011 for the causes of failures. Demographic data and underlying diagnosis for index primary TKA of the revision cases were compared to those of randomly selected primary TKAs during the same period.

Results One hundred forty revision TKAs and 4047 primary TKAs were performed at the five centers, indicating a revision burden of 3.3%. The most common cause of revision TKA was mechanical loosening (40%) followed by infection (24%), wear/osteolysis (9%), instability (9%), implant failure (6%), periprosthetic fracture (4%), and other reasons (8%). The mean age of patients with periprosthetic fracture was older (77 versus 72 years) and the male proportion in patients with infection was higher (33% versus 19%) than those of patients in the primary TKA group. There was no difference in BMI between primary TKAs and any type of revision TKA except other causes.

Conclusions The revision burden at the five referral centers in Hokkaido was 3.3%, and the most common cause of revision TKA was mechanical loosening followed

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by infection. Demographic data such as age and sex might be associated with particular causes of revision TKA.

Introduction

TKA is currently the international standard of care for treating degenerative and rheumatologic knee diseases and certain knee fractures. As the indications of TKA have been widened to include younger and more active patients, the demand for the procedure is increasing [13]. Therefore, the number of revision TKAs is also rising, with a projected increase of 601% from 2005 to 2030 in the United States [13]. Despite the functional outcomes and long-term implant survivorship reported with primary TKA [19], TKA failure and revision TKA remain substantial clinical challenges for orthopaedic surgeons and their patients.

Understanding the cause of failure and type of revision TKA procedures is essential in guiding TKA research, implant design, and clinical decision making. In the United States, Bozic et al. [3] reported infection, mechanical loosening, and implant failure or breakage were the most common causes of revision TKA in a series of 60,355 revision TKAs performed between October 1, 2005, and December 31, 2006. Data from the National Joint Registry for England and Wales [4] have also shown aseptic loosening and periprosthetic infection are the most common causes of revision TKA. One study from South Korea [12] showed an increase in the rates of TKA over time and higher rates in women than in men. Otherwise, epidemiologic data about rate of TKA and the age- and sex-standardized TKA rate from national registries of TKA have not been published for Asia, where more than 60% of the world population lives. In Japan, 63,430 patients underwent TKA in 2008 [20], and this number will likely increase as the population ages. A national database for Japan for collecting inpatient records was created in 2010 [10] but as of yet contains only 16,600 cases of TKA, combined in 2006 and 2007.

In Asian countries, people tend to use the squatting and kneeling postures in daily activities, such as for personal hygiene and house chores. These postures are risk factors for knee osteoarthritis (OA) and mechanical loosening of TKA. One study [22] suggested the magnitude of the difference between the sexes in the prevalence of symptomatic OA was greater in Asia than in the United States. Asians are generally smaller compared to whites. Because of differences in patient backgrounds and lifestyles, the causes of TKA failures in Asia may differ from those in Western countries.

We therefore determined (1) causes of revision TKA in a cohort of Japanese patients with revision TKA and (2) whether patient demographic features and underlying diagnosis of primary TKA are associated with the causes of revision TKA.

Patients and Methods

We retrospectively identified 4047 primary and 140 revision TKA procedures performed at five major referral centers in Hokkaido, Japan (Hokkaido University Hospital, Eniwa Hospital, Kushiro-Sanjikai Hospital, Abashiri Kousei Hospital, and Hakodate Central General Hospital), between February 2006 and May 2011. These hospitals cover patients in Hokkaido Island. Every surgeon was qualified by the board of orthopaedic surgery and had experience with TKA of more than 15 years. Sixty-two cases were referred from an outside institution. The mean interval from primary TKA to revision procedure was 73 months (range, 2–420 months). The minimum followup was 12 months (mean, 35 months; range, 12–132 months). No patients were recalled specifically for this study, and all data were obtained from medical records. There were no missing data for the 140 patients with revision TKA. The study was approved by each institution's institutional review board.

We identified 140 randomly selected patients from the 4047 patients with primary TKA to serve as a control group to the 140 patients with revision TKA; this group had undergone primary TKA at Hokkaido University Hospital during the same period. Female patients accounted for the majority of both primary and revision TKA procedures (81%) (Table 1). The mean age at surgery for the revision TKA group (72.9 years; 95% CI, 71.5–74.3 years) was similar to that for the primary TKA group (72.5 years; 95% CI, 71.2–73.8 years). The mean BMIs for the primary and revision TKA groups were also similar (26.8 kg/m^2 [95% CI, 26.0–27.5 kg/m^2] versus 26.9 kg/m^2 [95% CI, 26.2–27.7 kg/m^2]).

Antibiotics were used from just before surgery to 2 days after TKA routinely.

The cause of failure requiring revision surgery was determined by each surgeon using a full history, clinical examination, radiographic investigations, intraoperative findings, inspection of the explanted components, and results of blood examination and tissue cultures. We divided the revision TKA group into seven subgroups according to the cause of failure, including mechanical loosening, infection, wear/osteolysis, instability, implant failure, periprosthetic fracture, and other causes. The time between primary and revision TKA was 74 months (mechanical loosening subgroup), 31 months (infection subgroup), 139 months (wear/osteolysis subgroup), 91 months (instability subgroup), 169 months (implant failure subgroup), 72 months (periprosthetic fracture subgroup), and 26 months (other causes subgroup).

Table 1. Demographic data of the revision and primary TKA groups

Variable	Revision TKA group (n = 140)	Primary TKA group (n = 140)	p value	Odds ratio (95% CI)
Male/female (number of patients)	27/113	26/114	0.94	1.00 (0.97–1.03)
Age (years)*	72.9 (36–86)	72.5 (48–88)	0.84	1.06 (0.58–1.94)
Diagnosis (OA/RA/other) (number of patients)	120/17/3	115/24/1	0.20	0.62 (0.30–1.29)
BMI (kg/m^2)*	26.9 (16–39)	26.8 (18–38)	0.93	1.00 (0.94–1.05)

* Values are expressed as mean, with range in parentheses; OA = osteoarthritis; RA = rheumatoid arthritis.

Routine clinical and radiographic followup was undertaken at 3 months, 6 months, and yearly thereafter for all patients, including those referred from an outside institution. From the medical records and each hospital's database, we obtained demographic and clinical data, including sex, age, diagnosis for primary TKA, time from primary TKA to revision TKA, cause of failure, and BMI. Radiographic evaluation included analysis of limb alignment and radiolucencies per the Knee Society protocol [5]. Isolated wear with absence of concomitant osteolysis and migration was differentiated from mechanical loosening intraoperatively. Osteolysis was defined as a lesion greater than 5 mm^2 that was not present on immediate postoperative films [16]. Instability was evaluated using varus/valgus and anterior/posterior drawer stress radiograph. One person at each contributing institution reviewed all pre- and postoperative radiographs.

We performed bivariable and multivariable analyses to compare demographic variables between patients with primary and revision TKAs. In bivariable analyses, we used chi-square tests for comparison of categorical variables and unpaired t-tests for comparison of continuous variables. To account for potentially confounding variables, multivariate logistic regression was used to calculate odds ratios (ORs) and 95% CIs after controlling for potential confounders. Age, sex, diagnosis, and BMI were considered as explanatory variables in the model. For the analysis of reason for revision TKA, we determined differences in the ratio of men to women between the primary TKA group and each subgroup using the chi-square test. We determined differences in demographic factors associated with failure (age, diagnosis, BMI) between the primary TKA group and each subgroup using the unpaired t-test and the chi-square test. All statistical analyses were performed using Ekuseru-Toukei 2012 (Social Survey Research Information Co, Ltd, Tokyo, Japan).

Results

The causes of revision TKA in our cohort were mechanical loosening (40%), infection (24%), wear/osteolysis (9%), instability (9%), implant failure (6%), periprosthetic fracture (4%), and other causes (8%) (Table 2). Most procedures (87%) were all-component revision. However, eight of 11 patients in the other causes subgroup only underwent conversion to resurfacing of the patella.

Table 2. Causes for revision TKA

Cause for revision	Number of patients
Mechanical loosening	56 (40%)
Infection	33 (24%)
Wear/osteolysis	13 (9%)
Instability	13 (9%)
Implant failure	9 (6%)
Periprosthetic fracture	5 (4%)
Other causes	11 (8%)

Considering differences between the primary TKA group and each subgroup within the revision TKA group, the mean age was higher (p = 0.020) in the periprosthetic fracture subgroup (77 years) than in the primary TKA group (72 years) (Table 3). The percentage of male patients was higher (p = 0.036) in the infection subgroup (33%) than in the primary TKA group (19%). The mean BMI was higher (p = 0.047) in the other causes subgroup (30.5 kg/m^2) than in the primary TKA group (27 kg/m^2). Multivariate logistic regression for each subgroup indicated there was an increased risk of revision TKA for infection in male patients (OR = 2.73; 95% CI, 1.12–6.61; p = 0.03) (Table 4).

Discussion

While the modes of failure of TKA are well described in Western countries [2–4, 8, 17–19], the causes of revision TKA in Asia, especially Japan, are less frequently reported [1]. The key modes of failure in Western countries are aseptic loosening, infection, and implant failure or polyethylene wear [3, 8]. Owing to differences in patient backgrounds and lifestyles, the causes of TKA failures in

Table 3. Patient characteristics for the primary TKA group and the revision TKA subgroups

Variable	Primary TKA group (n = 140)	Mechanical loosening (n = 56)	Infection (n = 33)	Wear/ osteolysis (n = 13)	Instability (n = 13)	Implant failure (n = 9)	Periprosthetic fracture (n = 5)	Other causes (n = 11)
Age (years)*	73 (48–88)	72 (48–86)	71 (57–81)	75 (36–86)	76 (60–89)	74 (58–87)	77 (74–83)[‡]	76 (68–82)
Male/female (number of patients)	26/114	9/47	11/22[†]	2/11	1/12	2/7	0/5	2/9
Diagnosis (OA/RA/other) (%)	82/17/1	82/16/2	82/15/3	85/15/0	100/0/0	78/11/11	100/0/0	100/0/0
BMI (kg/m^2)*	27 (18–38)	26 (16–35)	26 (19–35)	28 (23–37)	27 (21–34)	27 (18–32)	27 (18–40)	31 (20–40)[§]
Time from primary TKA to revision TKA (months)*		74 (5–223)	31 (4–154)	139 (32–264)	91 (4–240)	169 (20–420)	72 (13–144)	26 (2–84)

* Values are expressed as mean, with range in parentheses; [†]p = 0.036, [‡]p = 0.020, [§]p = 0.047, compared with primary TKA group; OA = osteoarthritis; RA = rheumatoid arthritis.

Table 4. Multivariate logistic regression model for the revision TKA subgroups

Cause of revision TKA	Age		Male/female		Diagnosis		BMI	
	p value	Odds ratio (95% CI)	p value	Odds ratio (95% CI)	p value	Odds ratio (95% CI)	p value	Odds ratio (95% CI)
Mechanical loosening	0.39	1.02 (0.98–1.06)	0.82	0.90 (0.39–2.10)	0.18	0.49 (0.18–1.37)	0.53	1.02 (0.95–1.10)
Infection	0.08	1.05 (0.99–1.11)	0.03	2.73 (1.12–6.61)	0.67	0.79 (0.27–2.34)	0.22	1.07 (0.96–1.18)
Wear/osteolysis	0.17	0.94 (0.87–1.03)	0.62	0.67 (0.14–3.25)	0.66	1.45 (0.27–7.82)	0.28	0.93 (0.81–1.06)
Instability	NA	NA	NA	NA	NA	NA	NA	NA
Implant failure	0.57	0.97 (0.89–1.07)	0.83	1.20 (0.23–6.17)	0.58	1.64 (0.28–9.48)	0.98	1.00 (0.85–1.18)
Periprosthetic fracture	NA	NA	NA	NA	NA	NA	NA	NA
Other causes	NA	NA	NA	NA	NA	NA	NA	NA

NA = not applicable because of small number of patients in this subcategory.

Asia may differ from those in Western countries. We therefore determined (1) causes of revision TKA in a cohort of Japanese patients with revision TKA and (2) whether patient demographic features and underlying diagnosis of primary TKA are associated with the causes of revision TKA.

Our study is limited by a number of factors. First, this is a retrospective study that only included analysis of patients who had undergone revision TKA at five major centers in Hokkaido. Patients with indications for revision who had not undergone revision TKA due to their general condition and/or mild nature of their symptoms were excluded. However, the analysis did include those patients with substantial disability. Second, we had a limited number of cases available for analysis. Although there were only 140 revision TKA procedures, we did include all cases at the five centers between February 2006 and May 2011. Moreover, there were no missing data for all 140 revision TKAs. Third, we lacked a sufficient radiographic review and may have misclassified the reasons for revision TKA since we depended on the recorded descriptions of multiple investigators. However, every surgeon was qualified by the board of orthopaedic surgery and had experience with TKA of more than 15 years. Fourth, we did not consider the type of primary TKA implant in the revision TKA group. Sixty-two patients (> 40% of our cohort) were referred from an outside institution. Since different implants were used by each surgeon, it would have been difficult to compare the influence of the specific implant types. Fifth, we did not perform a power analysis before initiation of the study and the number of patients may be inadequate to properly assess instability, periprosthetic fracture, and other causes of failure; that is, there is a risk of a Type II error.

We found the major causes of revision TKA were mechanical loosening (40%), infection (24%), wear/osteolysis (9%), instability (9%), implant failure (6%), periprosthetic fracture (4%), and other causes (8%). In the United States, Bozic et al. [3] reported infection, mechanical loosening, and implant failure/breakage were the most common causes of revision TKA in a series of

Table 5. Previous studies of revision TKA

Study	Number of patients	Male/female (number of patients)	Mean age at revision TKA (years)	Years of operations	Followup times (years)	Top three causes of revision TKA
Sharkey et al. [17] (2002)	203	128/75	Men: 69 Women: 68	1997–2000	NA	Polyethylene wear: 25% Mechanical loosening: 24% Instability: 21%
Bozic et al. [2] (2005)	592	304/288	Single*: 68 Both†: 67	2000–2002	NA	Mechanical loosening: 35% Wear/osteolysis: 21% Instability: 20%
Vessely et al. [19] (2006)	45	NA	NA	1987–1989	14.5	Infection: 35% Aseptic loosening: 20% Polyethylene wear: 16%
Hossain et al. [8] (2010)	349	204/139	68	1999–2008	4.8	Infection: 33% Aseptic loosening: 15% Polyethylene wear: 12%
Bozic et al. [3] (2010)	60,355	25,711/34,644	66	2005–2006	NA	Infection: 25% Implant loosening: 16% Implant failure: 10%
UK National Joint Registry [4] (2008)	3377	1328/1459	70	2007	NA	Aseptic loosening: 38% Infection: 24% Pain: 17%
Current study	140	27/113	73	2006–2011	2.9	Mechanical loosening: 40% Infection: 24% Wear/osteolysis: 9%

* Single = single-component revision TKA; †both = both-component revision TKA; NA = not available.

60,355 revision TKAs (Table 5). Although polyethylene wear, aseptic loosening, and instability are common causes of TKA failure [17], Bozic et al. [3] and Vessely et al. [19] reported periprosthetic joint infection is currently the most common indication for revision TKA. The Swedish register reported an increase in the risk of early revision for 2006 to 2009 as compared to 2001 to 2005. A part of the increase was due to infected revisions in which only the inlay was exchanged [18]. Data from the National Joint Registry for England and Wales showed aseptic loosening (38%) and periprosthetic infection (24%) were the most common causes of revision TKA, as in our cohort [4]. However, pain was the third indication for revision TKA (17%) in England and Wales. The mean age at revision TKA in our study (73 years) was older than that in the study of Bozic et al. [3] (66 years). As the indications of TKA have been widened to include younger and more active patients, the demand for the revision procedure will be increasing. Odland et al. [15] reported 10 of 59 patients (11 of 67 knees) had revisions for aseptic loosening and/or osteolysis in patients 55 years of age and younger with OA with a minimum followup of 10 years.

We found age in the periprosthetic fracture subgroup was higher than that in the primary TKA group. Recent studies focusing on periprosthetic distal femur fractures reflect a trend toward older age in the study population [7]. We also found the percentage of male patients in the infection group was higher than that in the primary TKA group. The report from the Japanese Ministry of Health, Labour and Welfare demonstrated the smoking rate of men (32.2%) was higher than that of women (8.4%) [14]. Kapadia et al. [11] also stated TKA in smokers has a higher risk of negative clinical outcomes, including revision TKA, compared with nonsmokers. Lastly, we found the mean BMI of the revision TKA group was the same as that of the primary TKA group. However, the mean BMI of the other causes subgroup was higher than that in the primary TKA group. It has been reported revision TKA rates are higher in obese patients (BMI > 30 kg/m^2) than in nonobese patients [6]. The percentage of obese patients in our study was only 24.3%. This may be the reason BMI did not affect revision TKA rates in our study. Also, eight of 11 patients in the other causes subgroup only underwent conversion to resurfacing of the patella. We do not have evidence that higher BMI accounts for increasing resurfacing of the patella. In addition to these factors, squatting and kneeling, which people in Asian countries tend to use in daily activities, are strong risk factors for knee OA [21] and

mechanical loosening of TKA [9]. We assume mechanical loosening was the most common cause of TKA failure in our study because of the patients' lifestyle.

In conclusion, we demonstrated the most common causes of revision TKA were mechanical loosening and infection. Age in the periprosthetic fracture subgroup and percentage of male patients in the infection subgroup were higher than those in the primary TKA group. The BMI in the primary and revision TKA groups were the same, suggesting BMI did not contribute to the failure modes of primary TKA in our cohort study.

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