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Original article

Life expectancy of osteoarthritic patients after primary total knee arthroplasty☆

Yoshinori Ishii[a,*], Hideo Noguchi[a], Junko Sato[a], Hana Ishii[b], Satoshi Takayama[a], Shin-ichi Toyabe[c]

[a] Ishii Orthopaedic & Rehabilitation Clinic, 1089 Shimo-Oshi, Gyoda, Saitama 361-0037, Japan
[b] Kouseiren Takaoka Hospital, 5-10 Eirakutyo Takaoka, Toyama 933-8555, Japan
[c] Niigata University Crisis Management Office, Niigata University Hospital, Niigata University Graduate School of Medical and Dental Sciences, 1 Asahimachi Dori Niigata, Niigata 951-8520, Japan

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ABSTRACT

Background: Although an increased life expectancy has been previously reported in patients with osteoarthritis (OA) after undergoing total knee arthroplasty (TKA), the long-living Japanese population may provide a more accurate cohort for determining 10- and 15-year survival rates. The aims of the present study were to (1) determine the survival of patients after TKA, (2) identify the factors important for survival, and (3) compare the survival rate of the OA patients with that of the standardized general population.
Methods: The 5-, 10-, and 15-year survival rates were assessed in 326 consecutive OA patients treated with TKA from January 1998 to December 2013. Eighty-six of the cases were staged bilateral TKAs. All patients were followed until December 31, 2014 or until the time of death. The survival rate of the patients was compared with that of the standardized general population using Kaplan–Meier survival curves.
Results: Fifty-one of the patients died before the end of the follow-up. The cumulative 5-year patient survival was 93.5%, 10-year survival was 82.1%, and 15-year survival was 66.6%. The standardized mortality ratio was 0.916 (95% confidence interval: 0.682–1.204). A Cox proportional hazards model showed that increased age and unilateral TKA were factors related to higher patient mortality rates.
Conclusions: These data suggest that patients undergoing TKA can expect similar life expectancy as the general population, with 66.6% of such patients surviving for at least 15-years. Additionally, patients undergoing bilateral TKAs may have a longer life expectancy than those undergoing unilateral TKA.

1. Introduction

Primary total knee arthroplasty (TKA) is typically used to treat knee joint failure caused by osteoarthritis (OA).[1] The demand for primary TKA procedures is increasing and is projected to continue to grow each year in many countries. TKA is an effective treatment for alleviating knee pain, and patients often recover or improve their physical function. In fact, there is a large body of evidence demonstrating the positive effects of TKA for patients, such as cardiovascular fitness and a return to physical activity,[2] increased bone mineral density of the femur,[3] improved calcaneus bone quality,[4] voluntary quadriceps muscle activation,[5] and dynamic[6] or static body balance.[7] Additionally, several studies have suggested that an increased life expectancy in OA patients treated with TKA may be another positive effect of the treatment.[8–10]

Although many studies have reported short-term mortality after TKA, many of them primarily compared the outcomes among unilateral TKA and simultaneous and staged bilateral TKAs.[11–17] However, several studies have analyzed mid-term or long-term patient survival after TKA. Based on those reports, rheumatoid arthritis (RA),[9,10,18,19] male sex,[9,10] age[9,10,19,20], American Society of Anesthesiologist (ASA) grade,[19,21] body mass index (BMI),[19] diabetes,[8] and history of smoking[19] of patients undergoing TKA are

☆ The present work was performed at the Ishii Orthopaedic and Rehabilitation Clinic, 1089 Shimo-Oshi, Gyoda, Saitama, 361-0037, Japan.

* Corresponding author.
E-mail addresses: ishii@sakitama.or.jp (Y. Ishii), hid_166super@mac.com (H. Noguchi), jun-sato@hotmail.co.jp (J. Sato), hanamed12@gmail.com (H. Ishii), kango@ishii-clinic.gr.jp (S. Takayama), toyabe@med.niigata-u.ac.jp (S.-i. Toyabe).

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reported to be linked to increased mortality in populations mainly from the US[8] and European countries.[10],[18–20] Japan appears to be unique in that the number of TKAs performed here has more than doubled from approximately 30,000 to 70,000 per year[22] over the past 10 years and in that the Japanese population has had the longest extension in life expectancy in the world observed over the past few decades.[23]

The aims of the present study were to (1) determine the survival of TKA patients, (2) identify the factors important for their survival, and (3) compare the survival rates of the OA patients with those of the standardized survival rates from general Japanese population. Thus, the hypothesis of this study was that the unique expansion of the aging population in Japan provides an opportunity to determine the life expectancy of patients after TKA, which may inform patients in other countries.

2. Materials and methods

A total of 326 consecutive patients undergoing TKAs from January 1998 to December 2013 in our facility were investigated. All surgeries were performed by a single surgeon (Y.I.) using a standardized technique. All patients were all followed until December 31, 2014 or death. The preoperative diagnosis indicating TKA was OA. All of the 240 unilateral TKA patients also showed contralateral knee OA at the time of the initial TKA operation, and were assessed by the Kellgren–Laurence OA grade[24] as I (N = 13), II (N = 53), III (N = 74), and IV (N = 100) using weight-bearing standing X-rays. For statistical reasons, only the first operation was included in the present assessment of the 86 patients with bilateral implants. All of these patients underwent scheduled, staged, bilateral TKA. The choice of which side to operate on first was made based on patient preference (when their knee complications including pain and disability were similar on both sides). The second TKA was then performed based on each patient's preference concerning their ability to tolerate additional pain and limitations in their daily activities. The average follow-up duration was 95 months (range: 3–202 months). The mean age of the female patients (N = 280) was 72 (range: 42–90) years, and the mean age of the male patients (N = 46) was 70 (range: 34–84) years.

The starting point for the survival analysis was the date of the first TKA. The patients were then followed until December 31, 2014 or death. The overall survival of the patients after the first TKA was analyzed using the Kaplan–Meier method, and the factors contributing to statistically significant differences in survival were identified using log-rank tests with Bonferroni-corrected multiple comparisons. Previous studies[8–10,19,20,25] have suggested that a variety of factors influence survival after TKA. Among these factors, we determined the effects of age at the time of surgery, sex, unilateral versus bilateral surgery, ASA physical status before surgery, BMI, smoking status, use of anticoagulation medication, and presence of complicated diseases such as hypertension, hyperlipidemia, and diabetes mellitus on patient survival. Multivariate Cox regression analysis was performed to determine the factors that were most strongly associated with patient survival.

The expected mortality rate of the patients after the first TKA was calculated based on the age- and sex-specific mortality rates in the Japanese population from 2000 to 2015.[26] The standardized mortality ratio (SMR) was calculated by dividing the observed number of deaths by the expected number of deaths. The 95% confidence intervals (CI) of the SMR were calculated, and the statistical significance of each SMR was assessed using the chi-square test for fitness. The statistical analyses were performed in IBM SPSS Statistics ver. 20 (IBM Japan, Tokyo, Japan). P-values less than 0.05 were considered statistically significant.

3. Results

During the follow-up period, 51 of the 362 patients died. Their causes of death after TKA are shown in Table 1. None of the patients died from TKA surgery-related complications. The cumulative 1-year patient survival was 99.4%, 5-year patient survival was 93.5%, the 10-year patient survival was 82.1%, and the 15-year patient survival was 66.6% (Fig. 1A).

The univariate analysis showed that age at TKA ($p < 0.001$) (Fig. 1B), bilateral vs. unilateral treatment ($p < 0.001$), and ASA grade ($p = 0.035$) were significantly related to the survival rate (Table 2), but there was no effect of patient sex (Fig. 1C, Table 2). Significant differences by age were also found between the 65 to 75 and over 75 groups ($p = 0.001$), and between the less than 65 and over 75 groups ($p = 0.007$), but no difference was found between the less than 65 and 65 to 75 groups ($p = 1.000$). The Cox proportional hazard model showed that the factors of unilateral treatment and advanced age were related to a higher mortality rate (Table 3). Because age was not a significant factor ($p = 0.585$) between unilateral and bilateral TKAs according to the Wilcoxon rank sum test, bilateral TKA was recognized as a positive factor for survival rate independent of age.

The SMR of this cohort of TKA patients was not significantly different ($p = 0.529$) than that of the general population. Furthermore, the SMRs of neither sex (female: $p = 0.527$; male: $p = 0.896$) nor any age group (<64 years old: $p = 0.218$; 65 to 74 years old: $p = 0.167$; ≥75: $p = 0.529$) were different (Table 4) than those of the general population (Table 5).

4. Discussion

The results of this study suggest three important findings. First, the overall survival rates were 0.994 at 1 year, 0.935 at 5 years, 0.821 at 10 years, and 0.666 at 15 years post-TKA. Second, the factors that significantly affected the survival rates as shown by univariate analysis were age, bilateral vs. unilateral treatment, and ASA grade. Of those three factors, age and bilateral vs. unilateral treatment were found by Cox multivariate analyses to be independent factors. Third, the mortality rate of the patients after TKA, as determined by SMR, was not significantly different from that of the general population.

This study has a few limitations. One is that the number of patients analyzed might be considered relatively low for this type of study. Another is that the proportion of males to females was unequal. This higher prevalence of OA and TKA operations in females is a common finding in Japanese ethnic groups. This might be explained by racial difference in disease demographics and sex-based distinctions in the incidence of bow-leggedness. Finally, because only patients in ASA I or II were included, there were no patients who suffered from more debilitating medical conditions that substantially increased their risk of serious perioperative complications or death. Despite these limitations, this study has several advantages, including a 100% follow-up rate of the patients

Table 1
Causes of death in patients after total knee arthroplasty.

	Number
Malignancy	11
Pneumonia	11
Cerebrovascular disease	10
Cardiovascular disease	7
Senile Deterioration	7
Renal insufficiency	2
Digestive disease	1
Other (Accident etc.)	2
Total	51

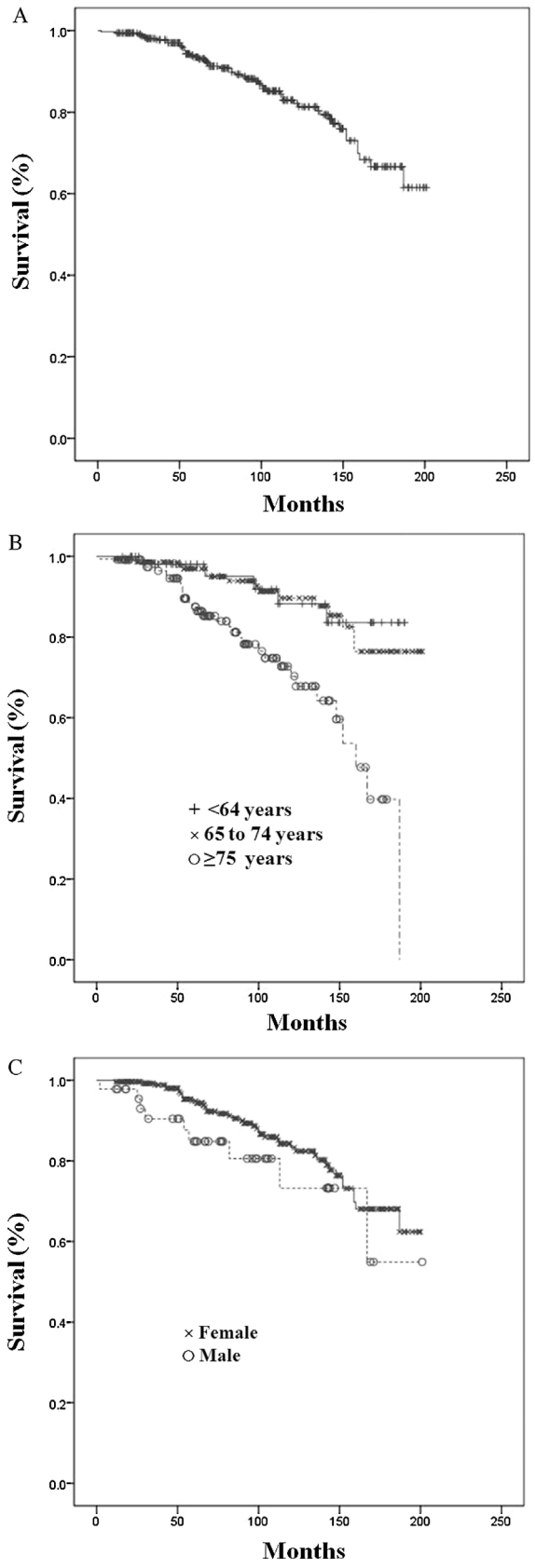

Fig. 1. (A) Kaplan–Meier survival curve for the overall population. (B) Kaplan–Meier survival curves for each age group. (C) Kaplan–Meier survival curves for females and males.

Table 2
Univariate analyses using the Kaplan–Meier procedure and Log-rank tests.

		N	1-year	5-year	10-year	15-year	p-value
Overall		326	0.994	0.935	0.821	0.666	
Laterality	Unilateral	240	0.992	0.907	0.758	0.601	<0.001
	Bilateral	86	1.000	1.000	0.958	0.802	
Gender	Female	280	0.996	0.949	0.824	0.681	0.159
	Male	46	0.978	0.848	0.733	0.549	
age group	<65	57	1.000	0.980	0.882	0.836	<0.001
	65–74	149	0.993	0.969	0.897	0.854	
	≥75	120	0.992	0.875	0.703	0.596	
ASA grade	I	62	0.984	0.962	0.939	0.814	0.035
	II	264	0.996	0.928	0.793	0.630	
BMI	<20	10	1.000	0.700	0.700	0.467	0.399
	20–35	306	0.993	0.942	0.826	0.674	
	>35	10	1.000	1.000	0.800	0.800	
Smoking	No	304	0.997	0.934	0.831	0.668	0.424
	Yes	22	0.955	0.955	0.668	0.668	
Hypertension	No	125	0.992	0.931	0.873	0.768	0.063
	Yes	201	0.995	0.937	0.793	0.607	
Hyperlipidemia	No	249	0.992	0.924	0.802	0.641	0.236
	Yes	77	1.000	0.970	0.892	0.766	
Anticoagulation	No	281	0.996	0.936	0.824	0.693	0.133
	Yes	45	0.978	0.925	0.807	0.314	
DM	No	289	0.993	0.939	0.819	0.690	0.226
	Yes	37	1.000	0.901	0.841	0.491	

N: number of patients; BMI: body mass index; ASA: American Society of Anesthesiologists; DM: diabetes mellitus.

who were all treated by a single, experienced surgeon and underwent the same postoperative rehabilitation protocol and mid- or long-term follow-up analysis (average: 8 years; maximum: 16 years).

The cumulative 1-year patient survival was 99.4%, 5-year patient survival was 93.5%, 10-year patient survival was 82.1%, and 15-year patient survival was 66.6%. The values for the 10-year survival were within the previously reported range[9,10,18–20] (Table 5). Based on the present study, two out of three patients (66.6%) undergoing TKA surgery can generally expect to live for 15 years, which is longer than indicated by previous reports.[18,20] We believe that this information may be useful to surgeons when explaining the probabilistic survival rates after TKA to patients.

A number of studies[9,10,18,19] have reported that the survival rate of patients with RA is lower than that of OA patients. Because only OA patients were followed up in the present study, other factors that may have affected the survival rate were evaluated. The factors of advanced age[9,10,19] and ASA grade[19] were also investigated in previous work. Interestingly, the patients who underwent bilateral TKA showed better survival rates than those receiving unilateral treatment as assessed by both the univariate and Cox multivariate analyses.

A few studies[6,27] have reported better clinical outcomes after bilateral compared with unilateral TKA surgery. Zeni et al.[27] reported that patients who underwent unilateral TKA had a

Table 3
Results from the Cox proportional hazard model.

	B	SE	p-value	Exp(B)	95% CI for Exp(B)	
					Lower	Upper
laterality (bilateral)	−1.476	0.437	0.001	0.229	0.097	0.538
age (continuous)	0.104	0.023	<0.001	1.110	1.060	1.162
ASA (II)	0.696	0.484	0.151	2.005	0.777	5.178

Exp(B): expectation of the (B) hazard ratio; SE: standard error; ASA: American Society of Anesthesiologists; CI: confidence interval.

Table 4
Standard mortality rates for the overall population, each sex, and each age group.

Variables	Group	N	Observed deaths	Expected deaths	SMR	95% CI	p-value
Overall		326	51	55.7	0.916	0.682–1.204	0.529
Sex	Female	280	42	46.3	0.907	0.654–1.226	0.527
	Male	46	9	9.4	0.957	0.438–1.818	0.896
Age group	<65	57	5	2.9	1.724	0.560–4.024	0.218
(years)	65 to74	149	15	21.4	0.701	0.392–1.156	0.167
	≥75	120	31	31.4	0.987	0.671–1.401	0.743

N: number of patients; SMR: standard mortality ratio; CI: confidence interval.

Table 5
Cumulative OA patient survival rates by year.

Study	Year	Mean Age[a] (range)	1-year	5-year	10-year	15-year
Schrøder et al.[b] [10]	1998	71[c] (23–88)		89%		
Böhm et al.[d] [18]	2000	72(46–87)		Approx. 96%[e]	Approx. 70%[e]	Approx. 10%[e]
Ohzawa et al.[9]	2001	68.4(42–83)		95.5%	95.5% at 9-year	
Robertsson et al.[20]	2007	71(25–96)		Approx. 90%[e]	Approx. 70%[e]	Approx. 40%[e]
Clement et al.[19]		69.3(28–94)	99%	90%	84%	
Lovald et al.[8]	2014	No description	96.9%	77.1%	65.6% at 7-year	

Avg.: average, Approx.: approximate.
[a] At the time of operation.
[b] Including outcomes of both osteoarthritis and rheumatoid arthritis patients.
[c] Median value.
[d] Including only females.
[e] Values were estimated from the Kaplan–Meier survival curves in each paper because the definite values were not reported.

significant increase in BMI and body mass, whereas patients treated with bilateral TKA and the controls did not. The authors speculated that increased pain or decreased function in the non-operated knee may reduce a unilateral TKA patient's ability to perform activities that would facilitate weight loss. Bakirhan et al.[6] reported that patients treated with bilateral TKA had significantly better performance at the limits of stability during dynamic balance evaluations than those treated with unilateral TKA by comparing the dynamic body balance parameters between unilateral and bilateral TKA. They concluded that patients treated with bilateral TKA had better dynamic balance, which is important for performing the activities of daily living. Finally, Ritter et al.[25] reported that at 10 years postoperatively, their bilateral group had a higher rate of survival (78.6%) compared with the unilateral group (72.0%), even though the bilateral TKA procedures were undertaken simultaneously.

In fact, two studies[28,29] have reported the positive effects of a second TKA in staged bilateral TKAs. By comparing the functional outcomes between the first and second knee replacement in patients undergoing staged bilateral TKAs, improvements were found after the second procedure in walking ability, use of walking aids, and psychological wellbeing.[28] Qutob et al.[29] conducted a retrospective cohort study of 668 staged bilateral TKA patients to determine the first-side versus second-side subjective and objective outcomes. Their results indicate that patients who showed a minimal clinically important improvement (MCII) on the first-side had a significantly greater chance of maintaining or improving that benefit after the second-side TKA. Of those with no clinical improvement (NCI), 71.4% achieved MCII on the second-side, while 28.6% remained NCI. The authors concluded that patients who do not initially benefit from first-side TKA should not be denied second-side staged-TKA because they still have a significant chance of achieving an MCII.

In the present study, all of the patients in the unilateral TKA group showed OA in the contralateral side, though the OA grades were variable. A population-based cohort study of 1163 patients in the southwest of England identified OA of the hip and knee as associated with an increased all-cause mortality rate, with a standardized mortality of 1.55.[30] The results of previous studies[6,27–30] and the present study together suggest that patients undergoing bilateral TKAs may have a longer life expectancy than patients undergoing unilateral TKA who have OA in the contralateral knee. Therefore, in terms of long-term survival, bilateral TKA surgery may lead to a better outcome when overcoming high mortality rates, especially in cases of simultaneous surgery over a relatively short postoperative period.[11,14,15,17]

Controversy remains in the literature with regards to the effects of TKA on SMR. Some studies report positive effects,[8–10] while others found negative effects[19] or no differences[18] compared with the general population. TKA patients had a longer survival time than the general population, especially women >75 years old with arthrosis.[10] Additionally, younger age (<55 years),[20] advanced age,[9,19] and male sex[9,10] were negative factors of survival compared with the general population. Finally, Lovald et al[8] demonstrated that Medicare patients treated with TKA for knee OA were associated with improved survivorship and reduced cardiovascular conditions. In the present study, the SMR of the TKA patients was not significantly different from that of the general population, though the advanced age group showed a higher mortality rate than the younger age group. Furthermore, no differences were found by sex or age. Although TKA is not a positive factor for life expectancy, it is also not a negative factor when compared with the Japanese population, which has the longest life expectancy in the world.

5. Conclusions

Patients undergoing TKA can expect no significant difference in life expectancy compared with the general population, and two out of three such patients (66.6%) can generally expect to live for at

least 15 years, based on the results of this study. Additionally, patients undergoing bilateral TKAs may have a longer life expectancy than those treated with unilateral TKA.

Conflict of interest

The authors have none to declare.

Ethical review committee statement

The local institutional review board approved this study. All patients provided informed consent.

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References

1. No author listed. NIH Consensus Panel. NIH consensus statement on total knee replacement December 8–10, 2003. *J Bone Joint Surg Am*. 2004;86(6):1328–1335.
2. Ries MD, Philbin EF, Groff GD, Sheesley KA, Richman JA, Lynch Jr. FJr.. Improvement in cardiovascular fitness after total knee arthroplasty. *J Bone Joint Surg Am*. 1996;78(11):1696–1701.
3. Ishii Y, Yagisawa K, Ikezawa Y. Changes in bone mineral density of the proximal femur after total knee arthroplasty. *J Arthroplasty*. 2000;15(4):519–522.
4. Ishii Y, Noguchi H, Sato J, Yoshioka Y, Toyabe SI. Bone quality of the calcaneus 5 years after total knee arthroplasty. *J Arthroplasty*. 2015;30(2):196–198.
5. Berth A, Urbach D, Awiszus F. Improvement of voluntary quadriceps muscle activation after total knee arthroplasty. *Arch Phys Med Rehabil*. 2002;83(10):1432–1436.
6. Bakirhan S, Angin S, Karatosun V, Unver B, Günal I. A comparison of static and dynamic balance in patients with unilateral and bilateral total knee arthroplasty. *Eklem Hastalik Cerrahisi*. 2009;20(2):93–101.
7. Ishii Y, Noguchi H, Takeda M, Sato J, Kishimoto Y, Toyabe S. Changes of body balance before and after total knee arthroplasty in patients who suffered from bilateral knee osteoarthritis. *J Orthop Sci*. 2013;18(5):727–732.
8. Lovald ST, Ong KL, Malkani AL, et al. Complications, mortality, and costs for outpatient and short-stay total knee arthroplasty patients in comparison to standard-stay patients. *J Arthroplasty*. 2014;29(3):510–515.
9. Ohzawa S, Takahara Y, Furumatsu T, Inoue H. Patient survival after total knee arthroplasty. *Acta Med Okayama*. 2001;55(5):295–299.
10. Schrøder HM, Kristensen PW, Petersen MB, Nielsen PT. Patient survival after total knee arthroplasty. 5-year data in 926 patients. *Acta Orthop Scand*. 1998;69(1):35–38.
11. Bolognesi MP, Watters TS, Attarian DE, Wellman SS, Setoguchi S. Simultaneous vs staged bilateral total knee arthroplasty among Medicare beneficiaries, 2000–2009. *J Arthroplasty*. 2013;28(8 Suppl):87–91.
12. Hu J, Liu Y, Lv Z, Li X, Qin X, Fan W. Mortality and morbidity associated with simultaneous bilateral or staged bilateral total knee arthroplasty: a meta-analysis. *Arch Orthop Trauma Surg*. 2011;131(9):1291–1298.
13. Kim YH, Choi YW, Kim JS. Simultaneous bilateral sequential total knee replacement is as safe as unilateral total knee replacement. *J Bone Joint Surg Br*. 2009;91(1):64–68.
14. Meehan JP, Danielsen B, Tancredi DJ, Kim S, Jamali AA, White RH. A population-based comparison of the incidence of adverse outcomes after simultaneous-bilateral and staged-bilateral total knee arthroplasty. *J Bone Joint Surg Am*. 2011;93(23):2203–2213.
15. Memtsoudis SG, González Della Valle A, Besculides MC, Gaber L, Sculco TP. In-hospital complications and mortality of unilateral, bilateral, and revision TKA: based on an estimate of 4,159,661 discharges. *Clin Orthop Relat Res*. 2008;466(11):2617–2627.
16. Poultsides LA, Memtsoudis SG, Do HT, Sculco TP, Figgie MP. Perioperative morbidity and mortality of same-admission staged bilateral TKA. *Clin Orthop Relat Res*. 2015;473(1):190–197.
17. Stefánsdóttir A, Lidgren L, Robertsson O. Higher early mortality with simultaneous rather than staged bilateral TKAs: results from the Swedish Knee Arthroplasty Register. *Clin Orthop Relat Res*. 2008;466(12):3066–3070.
18. Böhm P, Holy T, Pietsch-Breitfeld B, Meisner C. Mortality after total knee arthroplasty in patients with osteoarthrosis and rheumatoid arthritis. *Arch Orthop Trauma Surg*. 2000;120(1–2):75–78.
19. Clement ND, Jenkins PJ, Brenkel IJ, Walmsley P. Predictors of mortality after total knee replacement: a ten-year survivorship analysis. *J Bone Joint Surg Br*. 2012;94(2):200–204.
20. Robertsson O, Stefánsdóttir A, Lidgren L, Ranstam J. Increased long-term mortality in patients less than 55 years old who have undergone knee replacement for osteoarthritis: results from the Swedish Knee Arthroplasty Register. *J Bone Joint Surg Br*. 2007;89(5):599–603.
21. American Society of Anaesthesiologists Physical Status Classification System http://www.asahq.org/resources/clinical-information/asa-physical-status-classification-system.
22. No author listed. *Orthopaedic medical device market in Japan 2011. Artificial joint: artificial knee joint market*. Yano Research Institute; 2001:83–91.
23. Sasaki T, Izawa M, Okada Y. Current trends in health insurance systems: OECD countries vs Japan. *Neurol Med Chir (Tokyo)*. 2015;55(4):267–275.
24. Kellgren JH, Lawrence JS. Radiographical assessment of osteoarthritis. *Ann Rheum Dis*. 1957;16(4):494–502.
25. Ritter MA, Harty LD, Davis KE, Meding JB, Berend M. Simultaneous bilateral, staged bilateral, and unilateral total knee arthroplasty: a survival analysis. *J Bone Joint Surg Am*. 2003;85(8):1532–1537.
26. Ministry of Health, Labour and Welfare of Japan http://www.mhlw.go.jp/toukei/saikin/hw/seimei/list54-57-02.html.
27. Zeni Jr. JAJr., Snyder-Mackler L. Clinical outcomes after simultaneous bilateral total knee arthroplasty: comparison to unilateral total knee arthroplasty and healthy controls. *J Arthroplasty*. 2010;25(4):541–546.
28. Gabr A, Withers D, Pope J, Santini A. Functional outcome of staged bilateral knee replacements. *Ann R Coll Surg Engl*. 2011;93(7):537–541.
29. Qutob M, Winemaker M, Petruccelli D, de Beer J. Staged bilateral total knee arthroplasty: does history dictate the future? *J Arthroplasty*. 2013;28(7):1148–1151.
30. Nüesch E, Dieppe P, Reichenbach S, Williams S, Iff S, Jüni P. All cause and disease specific mortality in patients with knee or hip osteoarthritis: population based cohort study. *BMJ*. 2011;342:d1165.