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KNEE ARTHROPLASTY

Long-term outcomes of unicompartmental knee arthroplasty in patients requiring high flexion: an average 10-year follow-up study

Seung-Suk Seo[1] · Chang-Wan Kim[4] · Chang-Rack Lee[4] · Yong-Uk Kwon[4] · Minkyung Oh[3] · Ok-Gul Kim[2] · Chang-Kyu Kim[1]

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Abstract

Introduction To evaluate the long-term survival of unicompartmental knee arthroplasty (UKA) in the Asian population and assess differences in clinical outcomes between mobile- and fixed-bearing UKA.

Materials and methods Among 111 cases of UKA that were performed by 1 surgeon from January 2002 to December 2009, we retrospectively reviewed 96 cases (36 mobile-bearing, 62 fixed-bearing) for this study. We examined cause of revision or failure, type of reoperation/revision, and duration from the surgery date to the revision upon reviewing the medical record. Survival analysis was conducted using the Kaplan–Meier method. Functional outcomes were evaluated based on range of motion and patient-reported outcome (PRO) measures (Knee Injury and Osteoarthritis Outcome Score) for cases with at least 8 years of follow-up (average, 10.2 years).

Results Overall, the 10-year survival was 88% [95% confidence interval (CI) 0.81–0.95], and the estimated mean survival time was 13.4 years (95% CI 12.5–14.2). In a comparison of survival between the mobile- and fixed-bearing groups, the former had a 10-year survival of 85% (95% CI, 0.72–0.97) and an estimated mean survival time of 13.5 years (95% CI 12.2–14.7) and the latter had a 10-year survival of 90% (95% CI 0.82–0.99) and an estimated mean survival time of 13.4 years (95% CI 12.3–14.4). Thus, there was no significant difference in survival between the two groups (log-rank test, $p=0.718$). In addition, no significant difference in functional outcomes was observed between the two groups ($p>0.05$ for all).

Conclusions UKA performed in the Asian population showed a relatively good functional outcome and survival rate at an average 10-year follow-up. No difference in survival and PROs was observed according to the bearing type. Although the present study demonstrated a good survival rate, similar to that in other Western studies, further studies investigating the impact of the Asian lifestyle on the long-term survival of UKA is necessary.

Keywords Unicompartmental knee arthroplasty · Outcome · Survival · Asian population

Introduction

Numerous studies have reported long-term clinical results of unicompartmental knee arthroplasty (UKA). Despite the slight difference in results among the studies, the 10–15-year survival rate is reported to be as high as 90% [1–7]. Based on these results, UKA is considered a useful treatment option in cases of osteoarthritis limited to a single compartment in the knee joint. UKA is divided into mobile- and fixed-bearing types according to the design of the polyethylene insert [8]. As with total knee arthroplasty (TKA), many studies have investigated the differences in clinical outcomes between the two designs in UKA. Although most previous studies reported good clinical outcomes for both designs, whether

✉ Chang-Rack Lee
leechangrack@inje.ac.kr

1 Department of Orthopedic Surgery, Haeundae Bumin Hospital, 584, Haeundae-ro, Haeundae-gu, Busan 48094, Republic of Korea

2 Department of Orthopedic Surgery, Bumin Hospital, 59, Mandeok-daero, Buk-gu, Busan 46555, Republic of Korea

3 Department of Pharmacology, Inje University College of Medicine, 75, Bokji-ro, Busanjin-gu, Busan 47392, Republic of Korea

4 Department of Orthopedic Surgery, Inje University Busan Paik Hospital, 75, Bokji-ro, Busanjin-gu, Busan 47392, Republic of Korea

survival differs according to the design is still controversial [1, 9, 10].

More evidence is required to prove the usability of UKA as a treatment method for osteoarthritis limited to a single compartment, because most of the previously mentioned long-term follow-up studies on UKA reported clinical outcomes for the Western population where only one bearing type was used. In addition, there are virtually no long-term studies comparing the clinical outcomes between mobile- and fixed-bearing UKA as these are mostly short- or mid-term studies [11–13]. We believe it is necessary to evaluate the long-term results of UKA using a sample including diverse races and nationalities. Asians frequently perform high-flexion activities in daily life, such as sitting cross-legged, kneeling, or squatting [14–16], which could affect survival or clinical outcomes in the long-term follow-up of UKA [17–20]. Hence, it is necessary to determine whether UKA performed in the Asian population shows results similar to those in the Western population.

The purpose of this study was to evaluate the long-term survival of UKA in the Asian population and assess the differences in clinical outcomes between mobile- and fixed-bearing UKA. We assumed that UKA performed in the Asian population would have good long-term survival, similar to that reported among the Western population, and that the clinical outcome would not differ according to the bearing design.

Materials and methods

This study was approved by our institutional review board. From January 2002 to December 2009, a total of 111 cases of medial UKA (44 mobile bearings, 67 fixed bearings) were performed by 1 surgeon in our institution. In this study, we included patients with a minimum follow-up of 8 years after UKA and those who underwent revision surgery due to implant-related problems regardless of the follow-up duration. Because this study assessed the long-term survival and clinical outcomes, patients with a follow-up duration < 8 years were excluded from the sample.

Two patients died due to medical problems prior to reaching the minimum follow-up (5 and 6 years after the surgery). In total, 96 UKA cases (86.5%) (36 mobile bearings, 60 fixed bearings) were included in the study. 13 patients were lost to follow-up (3.5–7.5 years after surgery). We attempted to contact the 13 patients, but could not reach them.

UKA was performed in patients with Kellgren–Lawrence [21] grade 3 or 4 osteoarthritis limited to a single compartment in the knee joint, or in patients with osteonecrosis. Contraindications for UKA were as follows: inflammatory arthritis, such as rheumatoid arthritis, osteoarthritis in multiple compartments, ligamentous instability, angular deformity over 10°, severe obesity, and flexion contracture over 10° or range of motion below 90° [20]. There was no absolute standard to determine the type of implant to be used. Implant type was randomly selected by the surgeon, without considering patient demographics or other factors such as osteoarthritis severity. No case required conversion to TKA during the performance of UKA.

Surgical procedures were followed as per company's brochure. The Oxford (Biomet, Warsaw, IN, USA) and Miller-Galante (Zimmer Inc., Warsaw, IN, USA) systems were used for mobile- and fixed-bearing UKA, respectively. The patients began range-of-motion exercises using continuous passive motion immediately after their surgery (or 1 day after surgery). Weight-bearing with a crutch or walker was permitted within a tolerable range. Patients were allowed full weight-bearing without a walker or crutch from 1 week after the surgery.

Weight-bearing whole-leg anteroposterior (AP), standing knee AP, knee lateral, Rosenberg, and Merchant views were used for the radiologic assessments. Lower extremity alignment and existence of implant loosening were examined using the radiographs taken prior to surgery and at the final follow-up. Lower extremity alignment was evaluated using the mechanical femorotibial angle, which was defined as an angle formed by a line connecting the center of the femoral head and the center of the knee joint with a line connecting the center of the knee and the center of the ankle on the weight-bearing whole leg AP view [22]. Loosening was defined as the change of implant position in serially obtained radiographs. Radiolucency thickness > 2 mm that was progressive and poorly defined was considered an indication of aseptic loosening [11, 23].

We assessed the follow-up duration, types of complications, types of reoperation/revision, and duration from the surgery date to the revision upon reviewing the medical records. Kaplan–Meier survival curve analysis was used for survival analysis where the endpoint was defined as revision for any reason. Survival was evaluated using the total number of cases (96 cases). In addition, we evaluated whether there was a survival difference between the mobile- (36 cases) and fixed-bearing groups (60 cases) using the log-rank test.

We evaluated the clinical outcomes of 83 cases (31 mobile bearings, 52 fixed bearings) with at least 8 years of follow-up using range of motion (ROM) and patient-reported outcome measures (PROs). The average follow-up duration was 10.2 years (range 8–15 years). The Knee Injury and Osteoarthritis Outcome Score (KOOS) [24] was used to evaluate the clinical results based on PROs using data obtained prior to the surgery and at the final follow-up.

We used IBM SPSS Statistics, version 25.0 (IBM Corp., Armonk, NY, USA) for statistical analysis. The significance level was set at $p < 0.05$. An independent t test was used to compare the PROs (KOOS) between the mobile- and fixed-bearing groups.

Results

Table 1 illustrates the overall demographics. There was no significant difference in pre- and postoperative demographic data and radiologic results between the mobile- and fixed-bearing groups. Overall, the 10-year survival was 88% (95% CI 0.81–0.95) and the estimated mean survival time was 13.4 years (95% CI 12.5–14.2; Fig. 1). A survival comparison between the mobile- and fixed-bearing groups (Fig. 2) showed that the mobile-bearing group had a 10-year survival of 85% (95% CI 0.72–0.97) and an estimated mean survival time of 13.5 years (95% CI 12.2–14.7). The fixed-bearing group had a 10-year survival of 90% (95% CI 0.82–0.99) and an estimated mean survival time of 13.4 years (95% CI 12.3–14.4). Hence, no significant difference in survival was seen between the two groups (log-rank test, $p = 0.718$).

In total, revision was performed in 13 cases. Five cases in the mobile-bearing group underwent revision (13.9%) due to

Table 1 Sample characteristics

	Mobile-bearing	Fixed-bearing	Total
Number of cases	36	60	96
Age at surgery	64.5 ± 6.7 (51–79)	61.8 ± 8.2 (44–81)	62.8 ± 7.7 (44–81)
Sex (*n*, male/female)	1/35	3/57	4/92
BMI (kg/m^2)	25.3 ± 2.7 (19.2–30.0)	25.2 ± 2.3 (21.0–30.0)	25.3 ± 2.4 (19.2–30.0)
Cause of arthroplasty	Osteoarthritis: 34 Osteonecrosis: 2	Osteoarthritis: 56 Osteonecrosis: 6	Osteoarthritis: 90 Osteonecrosis: 8
Preoperative mFTA	6.1 ± 2.9 (0.0–10.0)	6.7 ± 3.2 (0.5–10.1)	6.5 ± 3.1(0.0–10.1)

Data are reported as mean ± standard deviation (range)

mFTA mechanical femorotibial angle

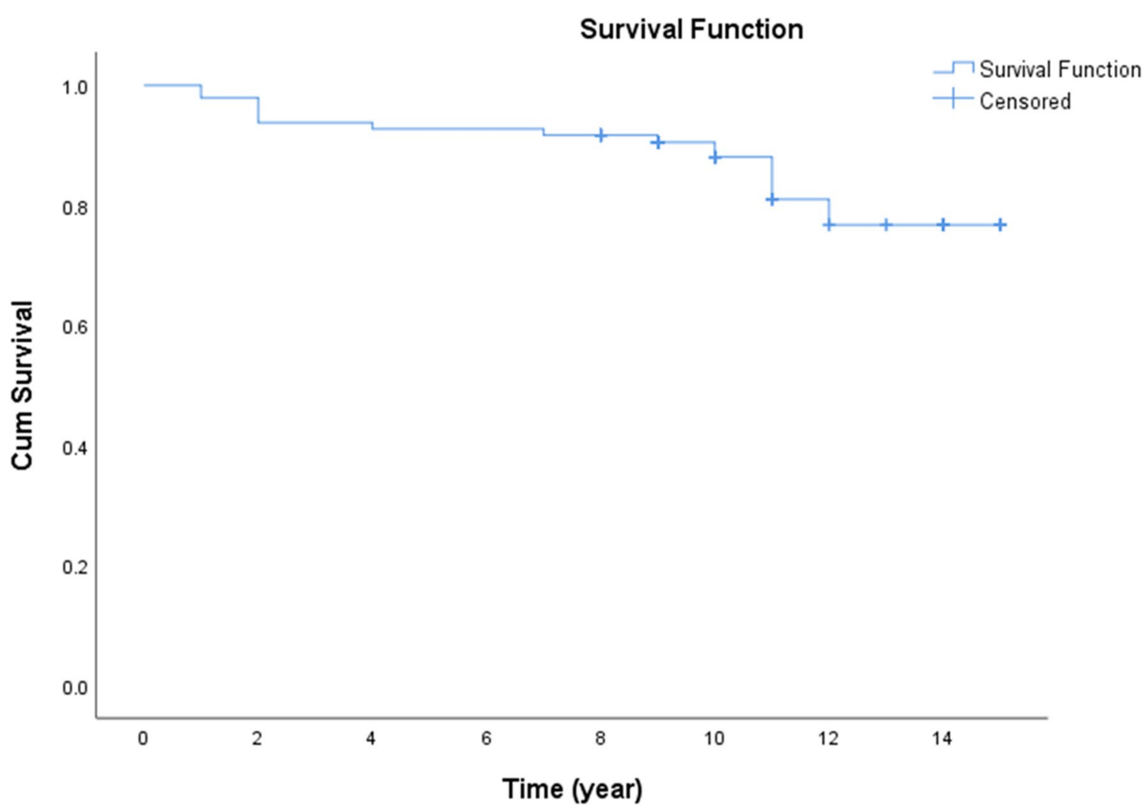

Fig. 1 Kaplan–Meier survivorship curve for total cases. Considering revision for any reason as the end point, the 10-year survival rate was 88% (95% CI 0.81–0.95), and estimated mean survival was 13.4 years (95% CI 12.5–14.2)

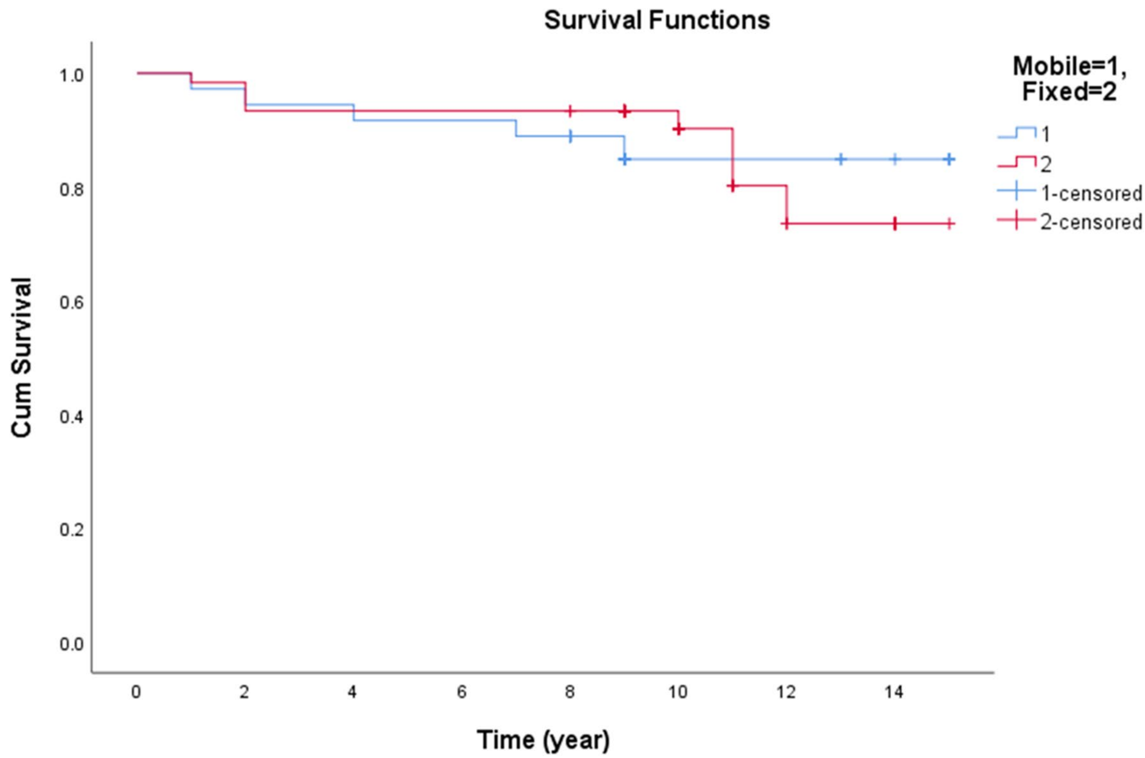

Fig. 2 Kaplan–Meier survivorship curve for mobile-bearing group and fixed-bearing group. Considering revision for any reason as the end point, the 10-year survival rate of the mobile-bearing group was 85% (95% CI 0.72–0.97), and the 10-year survival rate of the fixed-bearing group was 90% (95% CI 0.82–0.99). No significant difference in survival was seen between the two groups

wear of the polyethylene insert (2 cases), dislocation of the insert (2 cases), and aseptic loosening (1 case). Eight cases in the fixed-bearing group underwent revision due to aseptic loosening (2 cases), wear of the polyethylene insert (2 cases), osteoarthritis progression in the lateral compartment (2 cases), and periprosthetic joint infection (2 cases). Table 2 summarizes the specific details of the revision in each group.

Average ROM increased from 125.3° ± 7.4° before the surgery to 132.9° ± 7.3° after the surgery ($p < 0.001$), and all KOOS subscales demonstrated a statistically significant improvement ($p < 0.001$ for all). However, no significant difference was observed between the two groups in a comparison of preoperative and final follow-up ROM and PROs (KOOS score) (all subscales, $p > 0.05$; Table 3).

Discussion

In this study, the clinical outcomes and survival rates of UKA performed in the Asian population demonstrated good results at the 10-year follow-up. In addition, no significant difference was observed between mobile and fixed bearings. The current study showed good long-term survival, similar to that in previous studies of UKA performed in the Western population.

UKA has many advantages including faster recovery and improved range of motion [25–27]. The recent increased popularity of UKA is associated with improvements in implant design, surgical technique, and survival [28–31]. Numerous studies have reported excellent outcomes for

Table 2 Reasons for revision to total knee arthroplasty after unicompartmental knee arthroplasty

	Mobile bearing ($n = 5$)	Mean time to revision (years)	Fixed-bearing ($n = 8$)	Mean time to revision (years)
Aseptic loosening	1	2.3	2	2.7 (2.1–3.3)
Polyethylene wear	2	9.4 (8.6–10.2)	2	10.2 (9.2–11.1)
Dislocation	2	1.4 (1.2–1.7)	0	
Progression of arthritis	0		2	7.6 (2.7–12.5)
Infection	0		2	7 (1.9–12.1)

Table 3 Clinical results

	Total	Mobile-bearing	Fixed-bearing	*p* value*
ROM (°)				
Preoperative	125.3 ± 7.4	125.1 ± 7.5	125.5 ± 7.3	0.862
Postoperative	132.9 ± 7.3	133.8 ± 9.1	132.3 ± 6.1	0.310
Preoperative KOOS				
Pain	58.0 ± 14.7	57.8 ± 15.8	58.2 ± 14.1	0.898
Symptoms	60.0 ± 10.8	60.9 ± 10.3	59.5 ± 11.1	0.541
ADL	61.6 ± 15.8	61.8 ± 15.7	61.4 ± 16.0	0.905
Sport	24.5 ± 16.8	26.8 ± 16.1	23.8 ± 17.1	0.397
QOL	35.4 ± 15.2	37.0 ± 15.9	33.7 ± 14.6	0.303
Preoperative KOOS				
Pain	87.6 ± 10.0	88.3 ± 10.3	87.2 ± 9.9	0.605
Symptoms	87.4 ± 11.9	88.9 ± 10.2	86.4 ± 12.8	0.322
ADL	83.9 ± 10.2	85.7 ± 10.0	82.8 ± 10.3	0.180
Sport	34.3 ± 18.7	35.8 ± 17.8	33.3 ± 19.3	0.529
QOL	58.0 ± 14.2	58.1 ± 13.5	57.9 ± 14.7	0.947

*Mobile vs fixed bearing; ROM, range of motion; ADL, activities of daily living; sport, sport and recreation function; QOL, quality of life

UKA. The 10–15-year survival following UKA has been reported to be ≥ 90% [1–6]. However, existing studies on long-term survival of UKA have limitations—they have included mainly Western subjects. The major failure modes of UKA include progression of osteoarthritis, aseptic loosening, polyethylene wear, or polyethylene dislocation, etc. Several studies have investigated the difference in failure mode according to the time to failure of UKA due to complications or the design of the polyethylene insert [25, 32]. Asians frequently perform high-flexion activities in daily life, such as sitting cross-legged, kneeling, or squatting [14, 15, 30], whether such lifestyle activities affect the survival and long-term clinical results of UKA or TKA remains unclarified. Hence, long-term follow-up results of UKA or TKA on knee joints should be evaluated using subjects from more diverse nationalities, ethnicities, and races [30, 33]. Although Kim et al. [34] reported long-term follow-up results for UKA in Asian patients, their study was limited to those aged < 60 years using only the mobile-bearing type.

Kim et al. [34] reported a 10-year survival rate of 89.3% in a long-term follow-up study (average follow-up of 12.1 years) of 106 cases receiving Oxford UKAs. Xue et al. [30] reported the clinical results of UKA (mean follow-up of 6.2 years) in a Chinese population sample. In their study, 13 (1.88%) of 708 cases of medial Oxford UKAs underwent revision. The study reported a 5-year cumulative survival rate of 98.8% and a 10-year survival rate of 94.3%. In both studies, which reported mid- and long-term results of UKA among the Asian population, PROs and ROM were significantly improved after the surgery. Although the studies reported good clinical outcomes and survival rates for UKA among the Asian population, they have limitations that they involved a single type of UKA. In addition, Xue et al. [30] reported mid-term follow-up results, and the study of Kim et al. [34] was restricted to patients aged < 60 years.

Evaluation of the total UKA cases in the present study demonstrated a 10-year survival of 89.4% and a 14-year survival of 80.8%. The survival rate in the present study is similar to that in other studies at 10–15 years following UKA in a Western population or Asian population [1–5, 34]. Few studies have reported the correlation between high flexion and polyethylene wear or loosening in TKA. Several authors have reported that high flexion can affect survival, while others have argued that the two are not related, and this issue is still controversial [17–20, 35–37]. However, some studies have reported the correlation between a high flexion-related lifestyle and survival in UKA [33]. It is difficult to directly compare the difference in UKA results according to race or lifestyle. We can only indirectly evaluate them by referring to the UKA survival rates reported in other countries or cultural areas. These study results are meaningful as we demonstrated 10-year survival rates as high as 90% in Asian subjects with UKA who frequently perform high-flexion activities.

Mobile-bearing design has theoretical advantages over fixed-bearing design. Mobile-bearing type implant has congruent bearing with lower contact stresses and polyethylene wear rates [38–40]. However, which bearing type provides better clinical outcome in UKA remains to be clarified. In this study, no significant difference in survival or PROs was observed between the mobile- and fixed-bearing groups. Due to the small number of cases receiving revision, we could not conduct statistical analysis on the difference in the cause of failure between the two groups. Focusing only on implant-related issues rather than periprosthetic joint infection, loosening and polyethylene wear were commonly observed in both the mobile- and fixed bearing-groups. The occurrence timing of these complications was also similar in the two groups. Bearing dislocation and progression of osteoarthritis in the lateral compartment are among the main complications related to the survival following UKA. Ro et al. [33] reported that these two complications show different tendencies between Asian and Western patients. In a meta-analysis on complications following mobile-bearing UKA, they reported that reoperation due to osteoarthritis progression in the lateral compartment is frequently observed in the Western population, while reoperation due to bearing dislocation is frequently observed in the Asian population. In the current study, no case in the mobile-bearing group received revision due to the progression of osteoarthritis in the lateral compartment, although there were two cases of bearing dislocation in this group. The progression of osteoarthritis in the lateral compartment was observed only in the fixed-bearing group. Due to the number of cases included in this study, it is unclear whether these observations in our study are characterized by the Asian population. Further follow-up is necessary in the future.

This study has several limitations. First, only a small number of cases were included in this study. Second, this study examined case series that were implemented by one experienced surgeon in one institution. Hence, it is difficult to generalize the outcomes of this study to all Asian patients. However, our study is meaningful as few studies have examined the long-term results of UKA among the Asian population. Third, although gender was not included in the surgical indication, most recipients of UKA were female. Fourth, this study potentially has selection bias because the patients were not randomly allocated when choosing the types of bearings in UKA.

Conclusions

UKA performed in the Asian population demonstrated a relatively good functional outcome and survival rate at the average 10-year follow-up. No difference in survival or PROs was observed according to the bearing type. Although the survival rate in the current study was good, similar to rates in other studies evaluating a Western population, further studies are required to investigate the impact of an Asian lifestyle on the long-term survival of patients undergoing UKA.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interests.

Informed consent For this type of study formal consent is not required.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors. This study was approved by the Institutional Review Board in our institution (Inje University Busan Paik Hospital, IRB No. 18-0059).

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