Autologous Osteochondral Grafts for Knee Osteochondral Diseases Result in Good Patient-Reported Outcomes in Patients Older Than 60 Years

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Purpose: This study aims to examine the clinical autologous osteochondral grafts (AOG) outcomes for knee osteochondral diseases at operative ages >60 years, and to determine whether patients are able to sit straight in Japanese style after AOG. **Methods:** All patients who underwent AOG for knee osteochondral diseases between November 2001 and April 2018 were retrospectively identified. The inclusion criteria were AOG only without osteotomy, operative ages between 60 and 79 years, >2 years of follow-up, and involved femorotibial angle between 169° and 179° (normal alignment). Patients who underwent osteotomy to improve knee alignment and patients with inflammatory diseases such as rheumatoid arthritis were excluded. The patients' knee symptoms and their clinical outcome were evaluated according to the criteria of the knee scoring system of the Japanese Orthopedic Association (JOA), International Knee Documentation Committee (IKDC) subjective score, and the ability of straight sitting in Japanese style. **Results:** This study enrolled 57 cases and 60 knee joints during the study period. The follow-up ratio was 85.1%. Moreover, 14 men and 43 women and 29 right and 31 left knee joints were included in this study. The mean operative age and mean follow-up period were 67.8 years (range 60-76 years) and 81.1 months (range 24-167 months), respectively. In addition, the study involved 30 cases and 32 knee joints (60s group), and 27 cases and 28 knee joints (70s group). Moreover, 34 cases and 36 knee joints had osteonecrosis (ON group), and 23 cases and 24 knee joints had cartilage injury (CI group). The IKDC subjective and JOA scores in both the 60s and 70s groups showed significant differences: 2 years after AOG > at the follow-up period, > at the preoperative period. The scores in both the CI and ON groups showed similar significant differences. Furthermore, 8.3% and 53.5% of the patients could sit straight in Japanese style at the preoperative period and 2 years after AOG, respectively. **Conclusion:** Even if the patient's operative age was >60 years, the AOG only for their knee osteochondral diseases had good clinical outcomes, including the ability to sit straight in Japanese style. **Level of Evidence:** IV, Therapeutic case series Key words: autologous osteochondral grafts, aged patients, clinical outcome, knee joint, straight sitting in Japanese style

Autologous osteochondral grafts (AOGs) are increasingly used in the treatment of small, isolated, well-contained, articular cartilage defects.[1-6] The technique has been reported to have a good clinical outcome in osteochondral diseases (e.g., osteonecrosis and osteochondritis dissecans).[7,8] The long-term clinical outcome after AOG for a symptomatic osteochondral defect in the knee is good but varies greatly depending on age, sex, and lesion size.[9,10]

Cartilage function loss and quality are also seen with increasing age. A spectrum of diseases exists that range from focal cartilage defects (with healthy surrounding cartilage) to multiple and diffuse lesions (in osteoarthritic cartilage). Based on the studies on the treatment of degenerative lesions and early osteoarthritis, low-level evidence was noted to suggest that cartilage restoration is a possible treatment for such lesions, but conflicting results were noted on the effect of advanced

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age on the outcome.[11] Advanced age is one risk factor for failure after AOG and osteochondral allograft transplantation.[12] There were some reports that the indicative age limit for AOG was <40 or <50 years.[2,3]

However, good clinical AOG outcomes for knee osteochondral diseases at operative ages >60 years[13] were experienced. Moreover, the Japanese want to sit straight in Japanese style (seiza sitting; Fig 1), if possible. Asian people are commonly exposed to high-flexion activities (e.g., kneeling, squatting, and cross-legged sitting) in daily life for cultural reasons. The purposes of this study were to examine the clinical AOG outcomes for knee osteochondral diseases at operative ages >60 years and to determine whether patients are able to sit straight in Japanese style after AOG. The hypothesis of our study was that the AOG only for knee osteochondral diseases had good clinical outcomes, including the ability to sit straight in Japanese style, even if the patient's age at surgery was >60 years.

Methods

Patients who underwent AOG for osteochondral diseases between November 2001 and April 2018 were retrospectively identified. The inclusion criteria in this study were AOG for knee osteochondral diseases, AOG only without osteotomy, operative ages between 60 and 79 years, >2 years of follow-up, and involved femorotibial angle between 169° and 179° (normal alignment). The permitted combined operations were partial meniscectomy, anterior cruciate ligament reconstruction or lateral release. Patients who underwent osteotomy to improve knee alignment were excluded from the study. Patients with inflammatory conditions such as rheumatoid arthritis were also excluded. All procedures were reviewed and approved by the research ethics committee of the hospital of this study, and this study was carried out following the World Medical Association's Declaration of Helsinki. According to the treatment protocol for osteochondral diseases in the knee joints in the current study, high tibial osteotomy with AOG is performed if the femorotibial angle is >180°. However, distal femoral varus osteotomy with AOG is performed if the femorotibial angle is <168°. Therefore AOG is performed alone if the femorotibial angle is between 168° (valgus deformity) and 180° (varus deformity). The patients were divided into two groups according to operative age: between 60 and 69 years (60s group) and between 70 and 79 years (70s group).

The osteonecrosis or cartilage injury was diagnosed using radiography and magnetic resonance imaging. AOG for knee osteochondral diseases was performed if conservative treatment (e.g., nonsteroidal anti-inflammatory drugs, hyaluronic acid intraarticular injection, and muscle strength exercises) for more than 3 months had no effect. The minimum recipient area was 100 mm^2.

The operative procedures of this study were as follows. Knee arthroscopy was performed first. Moreover, partial meniscectomy was performed in some cases. A medial parapatellar approach was used if the recipient site was the medial femoral condyle. The curettage of the degenerative cartilage in the recipient site was done, and several autologous osteochondral plugs were implanted into the recipient site. The Osteochondral Autograft Transfer System (Arthrex, Naples, FL) was mostly used with an open technique for osteochondral grafts. However, a lateral parapatellar approach was used if the recipient site was the lateral femoral condyle. A medial parapatellar approach was used if the recipient site was the trochlea or patella, and plugs were obliquely implanted to create the curvature of the articular surface of both the patella and the trochlea. The postoperative rehabilitation program was the range of motion exercise (started 3 days after AOG), partial weightbearing gait (started in week 2 in the patellofemoral joints and week 3 or 4 in femorotibial joints), and full weightbearing gait (started in week 5 or 7). The patient donor site was either the far superior lateral or the medial trochlea (relatively nonweightbearing surface), and the donor plugs were harvested with knee in extension. In general, the donor defects were filled with bone chips from the recipient sites to the subchondral bone level and not to the articular cartilage surface.

The patients' knee symptoms as their clinical outcome were evaluated according to the following criteria: the

Fig 1. Straight sitting in Japanese style. The knee is in maximum flexion in the sitting position.

Table 1. Characteristics

	Age Groups			Disease Groups		
	60-69 years (30 cases 32 knees)	70-79 years (27 cases 28 knees)	*P* Values	Osteonecrosis (34 cases 36 knees)	Cartilage injury (23 cases 24 knees)	*P* values
Sex			.808			.237
Male	7	7		6 (17.6%)	8 (34.8%)	
Female	23	20		28 (82.4%)	15 (65.2%)	
Side			.809			.958
Right	15	14		18(50.0%)	11 (45.8%)	
Left	17	14				
Age (yr)	63.81 ± 2.74	72.29 ± 1.92	<.001	68.58 ± 4.8	66.63 ± 4.8	.127
Follow-up periods (mo)	85.86 ± 47.54	75.71 ± 37.63	.367	80.0 ± 39.6	82.8 ± 48.8	.806
Recipient site			.188			.006
MFC	19	22		30	11	
MFC + TR	5	11		3	1	
MFC + LT	1				1	
MT				1		
TR	3	3		1	5	
LFC	2				2	
LFC + LT	1	1			1	
LT	1					
TR + P		1			3	
P	1			1		
Recipient area (mm^2)	318.81 ± 163.43	315.36 ± 135.02	.930	333.1 ± 150.1	293.4 ± 148.0	.319
Diameter of plugs (mm)	8.00 ± 0.51	8.07 ± 0.66	.639	8.14 ± 0.49	7.88 ± 0.68	.085
Number of plugs	3.31 ± 1.4	3.14 ±1.3	.630	3.31 ± 1.4	3.13 ± 1.3	.615

MFC, medial femoral condyle; LFC, lateral femoral condyle; MT, medial tibia; LT, lateral tibia; TR, trochlea; P, patella.

knee scoring system of the Japanese Orthopedic Association (JOA)[14] and International Knee Documentation Committee (IKDC) subjective score, which is patient-reported outcomes, and objective scores.[15] Two senior orthopaedic surgeons (Y.N., S.M.) assessed the patients' clinical outcomes. The JOA scale evaluates the ability to walk (30 points), ability to climb up and down the stairs (25 points), range of motion (35 points), and joint swelling (10 points). Each knee joint can achieve a maximum score of 100 points on the JOA scale. A validation study for the JOA score was reported by Okuda et al.[16] Clinical outcomes in the preoperative period, 2 years after AOG, and at final follow-up were evaluated. Moreover, donor site morbidities and reoperative cases were examined.

This study also examined the changes in the Kellgren-Lawrence (KL) classification in plain anteroposterior or skyline view radiographies. A single senior orthopaedic surgeon (Y.N.) assessed the KL classification of all patients. KL classifications and the ability of straight sitting in Japanese style were also examined at the preoperative period, 2 years after AOG, and at final follow-up.

The clinical outcomes 2 years after AOG were compared with the preoperative clinical scores. The operative age, follow-up periods, the recipient area that was measured using a ruler, the number of implanted plugs, and the diameter of implanted plugs were also assessed. About 1 year after primary AOG, second-look arthroscopy was planned to examine the grafted articular cartilage. The recipient site was evaluated using the International Cartilage Repair Society (ICRS) cartilage repair assessment score.

The Mann-Whitney U-test, paired *t*-test, and χ^2 test were used to perform statistical analysis of various scores. Moreover, the level of statistical significance was set at $P < .05$.

Results

This study enrolled 57 cases and 60 knee joints from November 2001 to April 2018. The follow-up ratio was 85.1%. Moreover, 14 men and 43 women and 29 right and 31 left knee joints were included in this study. The mean operative age was 67.8 years (range 60-76 years), and the mean follow-up period was 81.1 months (range 24-167 months). The 60s group involved 30 cases and 32 knee joints with a follow-up ratio of 83.3%. The 70s group involved 27 cases and 28 knee joints with a follow-up ratio of 87.1%. The characteristics of the 2 age groups (e.g., recipient sites, recipient area, the diameter of the grafted plugs, and the number of grafted plugs) are shown in Table 1. No significant differences were noted between the 2 age groups except for the operative age. The basic diseases in this study were osteonecrosis and cartilage injury (including osteoarthritis). In addition, this study had 34 cases and 36 knee joints of osteonecrosis (ON group) and 23 cases and 24 knee joints of cartilage injury (CI group). The characteristics of the 2 diseases groups (e.g., recipient sites, recipient area, the diameter of grafted plugs, and the number of grafted plugs) are shown in Table 1. No

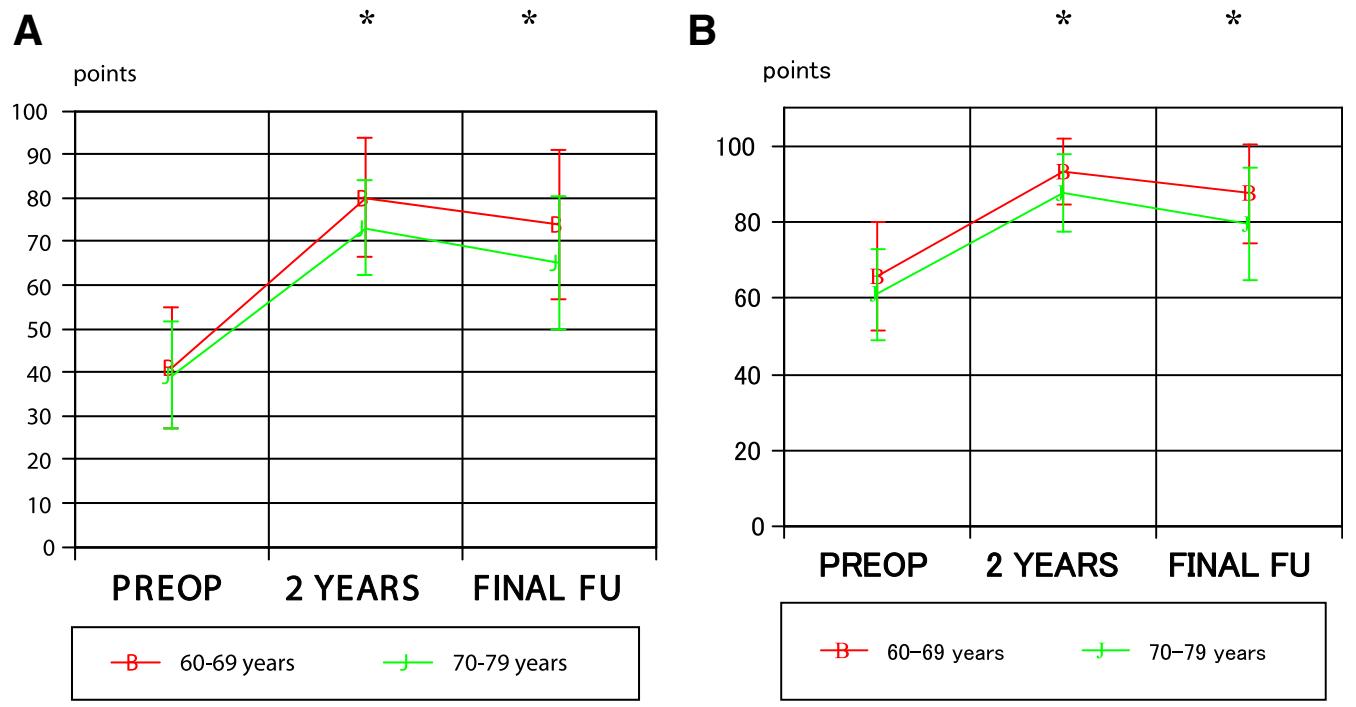

Fig 2. (**A**) The chronological changes of IKDC subjective scores in the 2 age groups (mean ± standard deviation). The IKDC subjective scores in the 60- to 69-year group were significantly higher than those in the 70- to 79-year group 2 years after AOG and at the follow-up period (asterisks). Both groups have improved IKDC scores at final follow-up compared to before surgery. (**B**) The chronological changes of JOA scores in the 2 age groups (mean ± standard deviation). The JOA scores in the 60- to 69-year group were significantly higher than those in the 70- to 79-year group 2 years after AOG and at the follow-up period (asterisks). Both groups have improved JOA scores at final follow-up compared to before surgery.

significant differences between the 2 diseases groups were noted except for the recipient site. The ratio of the medial femoral condyle in the ON group was significantly higher than that in the CI group.

Ten cases were lost to follow-up during less than 2 years because they discontinued coming to our hospital. Combined operation in lateral release (2 cases), anterior cruciate ligament reconstruction (1 case), lateral partial meniscectomy (4 cases), and medial partial meniscectomy (5 cases) were noted. In terms of clinical outcomes, the chronological changes of IKDC subjective score in the 2 age groups are shown in Figure 2A. The IKDC subjective scores in the 60s group were significantly higher than those in the 70s group at 2 years after AOG and at the follow-up period. Significant differences at 3 points (preoperative, follow-up, and postoperative 2 years) were noted. in the two groups. The chronological changes of JOA in the 2 age groups are shown in Figure 2B. The changes of JOA scores were same as those of the IKDC subjective scores.

In terms of clinical outcomes in the 2 disease groups, the chronological changes of the IKDC subjective score are shown in Figure 3A. The IKDC subjective score in the CI group was significantly higher than that in group ON only in the preoperative period. No significant differences in the two diseases groups 2 years after AOG and at the follow-up period were noted. Moreover, significant differences at 3 points (preoperative, follow-up, and 2 years after surgery) were noted in the 2 groups. The chronological changes of the JOA score are shown in Figure 3B. The JOA score in the CI group was significantly higher than that in the ON group only in the preoperative period. No significant differences were noted in the 2 disease groups 2 years after AOG and at the follow-up period. In the 2 groups, significant differences at 3 points (before surgery, follow-up, and 2 years after surgery) were noted.

The chronological changes of IKDC subjective and JOA scores in the 4 groups are shown in Figure 4. At the preoperative period, the IKDC subjective score in the 70s CI group CI was significantly higher than those in the 60s ON group and the 70s ON group, and that in the 60s CI was significantly higher than that in the 70s ON group. At 2 years after AOG, the IKDC subjective score in the 60s CI group was significantly higher than those in the 60s ON and 70s ON groups. At follow-up, the IKDC subjective score in the 60s CI group was significantly higher than that in the 70s CI group. In the 60s CI group and 70s ON group, the IKDC subjective scores at 2 years and follow-up were significantly higher than those in the preoperative period. In the 60s ON group, significant differences at 3 points (before

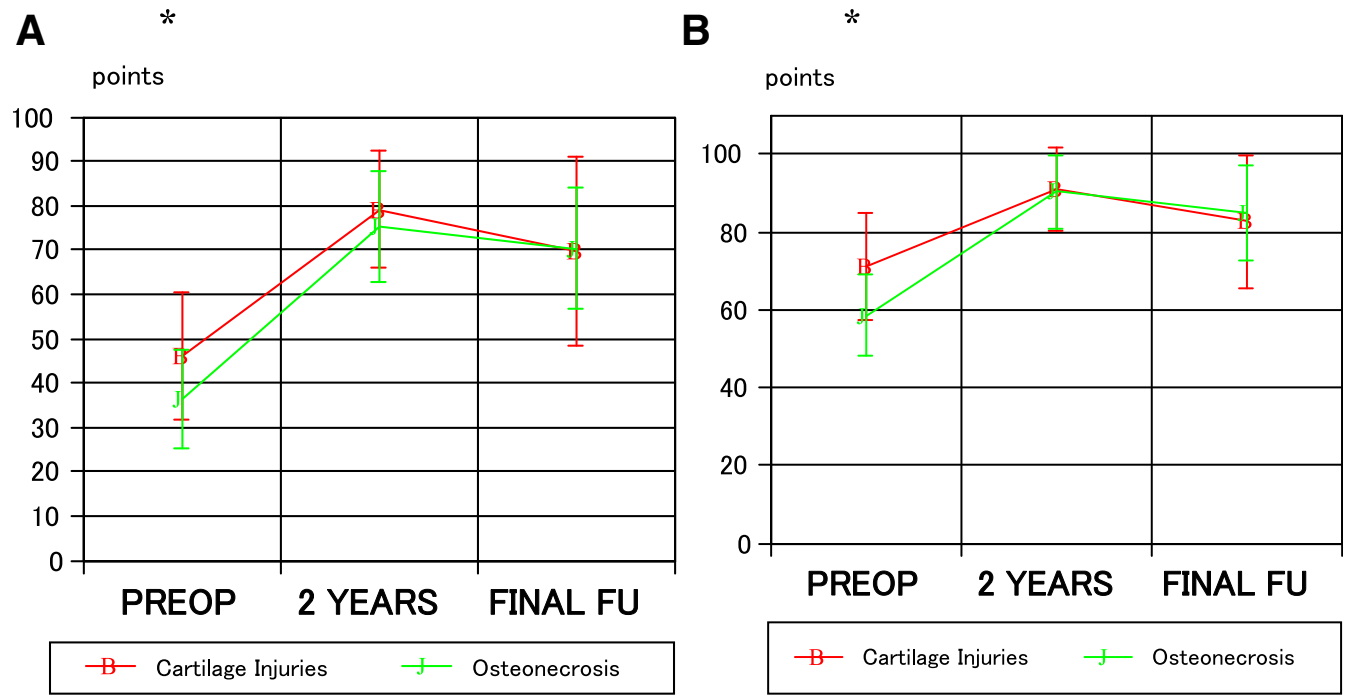

Fig 3. (**A**) The chronological changes of IKDC subjective scores in the 2 disease groups (mean ± standard deviation). The IKDC subjective score in the CI group was significantly higher than that in the ON group only in the preoperative period (asterisk). Both groups have improved IKDC scores at final follow-up compared to before surgery. (**B**) The chronological changes of JOA scores in the 2 disease groups (mean ± standard deviation). The JOA score in the CI group was significantly higher than that in the ON group only in the preoperative period (asterisk). Both groups have improved JOA scores at final follow-up compared to before surgery.

surgery, follow-up, and 2 years after surgery) were noted. In the 70s CI group, the IKDC subjective score at 2 years was significantly higher than that in the preoperative period. At the preoperative period, the JOA scores in the 60s CI and 70s CI groups were significantly higher than that in the 70s ON group. Moreover, 2 years after AOG, the JOA score in the 60s CI group was significantly higher than those in the 70s CI and 70s ON groups, and the JOA score in the 70s ON group was significantly higher than that in the 70s CI group. At follow-up, the JOA scores in the 60s CI and 60s ON groups and the 70s ON group were significantly higher than that in the 70s CI group. In the 60s CI group, the JOA scores at 2 years was significantly higher than that in the preoperative period. In the 60s ON and 70s ON groups, significant differences at 3 points (before surgery, follow-up, and 2 years after surgery) were noted. In the 70s CI group, the JOA score at 2 years was significantly higher than that at the follow-up period.

The minimal clinically important difference for IKDC subjective score was defined as a more than 10-point improvement from their preoperative scores.[17] In the 60s group, 30 knees (93.8%) improved at 2 years, and 25 knees (89.3%) improved at follow-up. In the 70s group, 26 knees (92.9%) improved at 2 years, and 18 knees (85.7%) improved at follow-up.

The chronological changes of the IKDC objective score in the 4 groups are shown in Tables 2. In all 4 groups, the number of patients who were more than nearly normal at 2 years after AOG and at final follow-up was significantly larger than of those in the preoperative period. No risk factors were noted in the IKDC objective score. Moreover, no donor site morbidities were noted in all cases. Three cases needed reoperation because of increasing knee pain. The operative ages were 64 years (woman; 142 months after AOG), 70 years (man; 123 months after AOG), and 76 years (woman; 61 months after AOG), and they had total knee arthroplasties (TKA). The reoperation ratios were 3.1%, 7.1%, 12.5%, and 0% in the 60s CI, 70s CI, 60s ON, and 70s ON groups, respectively.

The chronological changes of the KL classification in the four groups are shown in Table 3. Patients who were in grade 1 or 2 at 2 years after AOG were significantly higher than those in the preoperative period ($P = .0454$) in the 60s group. Moreover, the number of the grafted plugs in patients who were in grade 1 or 2 in KL classification at 2 years after AOG was prone to be smaller than that in the patients who were in grade 3 ($P = .0884$) (Fig 5).

The chronological changes of the ability of straight sitting in Japanese style are shown in Table 4. In the 60s

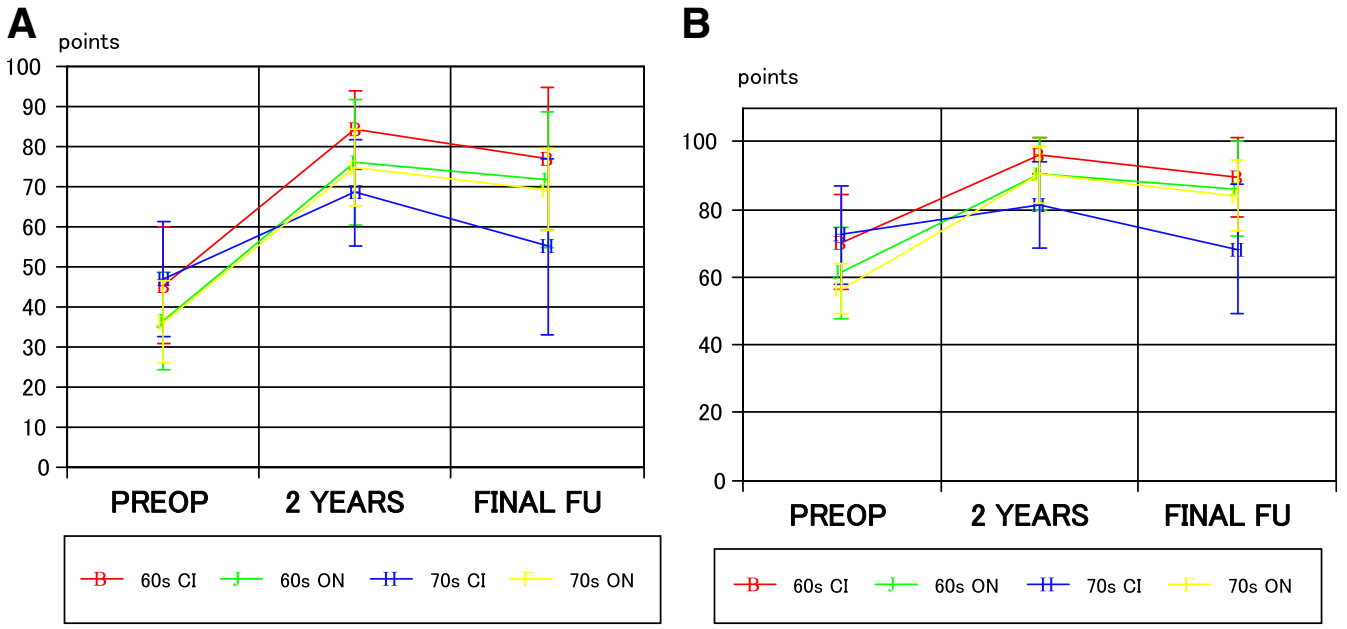

Fig 4. (**A**) The chronological changes of IKDC subjective scores in 4 groups (mean ± standard deviation). In the preoperative period, the IKDC subjective score in the 70s CI group was significantly higher than those in the 60s ON and 70s ON groups, and that in the 60s CI group was significantly higher than that in the 70s ON group. The IKDC subjective score in the 60s CI group was significantly higher than those in the 60s ON and 70s ON groups 2 years after AOG. In the follow-up period, the IKDC subjective score in the 60s CI group was significantly higher than that in the 70s CI group. In the 60s CI group and the 70s ON group, the IKDC subjective scores at 2 years after AOG and follow-up were significantly higher than that in the preoperative period. The 60s ON group has improved IKDC scores at final follow-up compared to before surgery. In the 70s CI group, the IKDC subjective score at 2 years after AOG was only significantly higher than that in the preoperative period. (**B**) The chronological changes of JOA scores in 4 groups (mean ± standard deviation). In the preoperative period, the JOA scores in the 60s CI and 70s CI groups were significantly higher than that in the 70s ON group. At 2 years after AOG, the JOA score in the 60s CI group was significantly higher than those in the 70s CI and 70s ON groups, and the JOA score in the 70s ON group was significantly higher than that in the 70s CI group. During the follow-up period, the JOA scores in the 60s CI and 60s ON groups and the 70s ON group were significantly higher than that in the 70s CI group. In the 60s CI group, the JOA score at 2 years was significantly higher than that in the preoperative period. The 60s ON and 70s ON groups have improved JOA scores at final follow-up compared to before surgery. In the 70s CI group, the JOA score at 2 years after AOG was only significantly higher than that in the follow-up period.

ON and 60s CI groups, the number of patients who could sit straight in Japanese style 2 years after AOG and at final follow-up were significantly higher than those in the preoperative period. In the 70s group, more patients were able to sit straight in Japanese style 2 years after AOG compared with before surgery. Except for these, no significant differences were noted. Moreover, no significant differences at 3 points (preoperative, 2 years after AOG and final follow-up) were noted between the 60s and 70s groups, or between the CI and ON groups. In total cases, the diameter of the grafted plugs in the patients who could sit straight in Japanese style 2 years after AOG was significantly higher than that in the patients who could not sit straight in Japanese style ($P = .0268$) (Fig 6). Of the 20 patients who underwent second-look arthroscopy, 14 and 6 were assigned in the 60s and 70s groups, respectively. The mean time from AOG to the second-look arthroscopy was 17.4 months (range 12-35 months). In the ICRS cartilage repair assessment during the second-look arthroscopy, the mean scores were 10.8 points (range 9-12) in the total cases, 10.8 points (range 9-12) in the 60s group, and 10.7 points (range 10-12) in the 70s group. In this series, no major complications were seen.

Discussion

The most important finding of this study is that patients who are over 60 years of age have improved clinical outcome scores at final follow-up after AOG compared to before surgery. Those scores in both the CI and ON groups showed similar significant differences. The scores in the 60s group were significantly higher than those in the 70s group 2 years after AOG and at the final follow-up period. Therefore the AOG only for their knee osteochondral diseases had good clinical outcomes, even if the patient's operative age was >60 years. However, the clinical outcomes became slightly worse if their follow-up period was longer. In

Table 2. The Chronological Changes of IKDC Objective Score By Age, Osteonecrosis, and Injury

Grade	Before Surgery	2 Years After	Follow-Up
60-69 years			
Normal	0	2	1
Nearly normal	1	17	12
Abnormal	24	13	14
Severely abnormal	7	0	1
70-79 years			
Normal	0	2	1
Nearly normal	1	13	9
Abnormal	22	13	10
Severely abnormal	5	0	1
Osteonecrosis			
Normal	0	3	1
Nearly normal	1	18	13
Abnormal	27	15	16
Severely abnormal	8	0	0
Cartilage injury			
Normal	0	1	1
Nearly normal	1	12	8
Abnormal	19	11	8
Severely abnormal	4	0	2

particular, the 70s CI group showed these tendencies, which may be due to degeneration caused by old age. With regard to the ability to sit straight in Japanese style, 8.3% and 53.5% of the patients could sit in the preoperative period and 2 years after AOG, respectively. Also, in this respect, AOG obtained good clinical outcomes even if the patient's operative age was >60 years.

Several reports of cartilage restoration in the degenerative aging knee were noted. Bone marrow stimulation is indicated for the treatment of full-thickness defects in articular cartilage without significant bone

Table 3. The Chronological Changes of KL Classification By Age, Osteonecrosis, and Injury

Grade	Before Surgery	2 Years After	Follow-up
60-69 years			
I	5	3	1
II	6	17	13
III	20	12	13
IV	1	0	1
70-79 years			
I	1	1	1
II	10	16	9
III	17	11	9
IV	0	0	2
Osteonecrosis			
I	3	2	1
II	17	20	14
III	16	14	15
IV	0	0	0
Cartilage injury			
I	3	2	1
II	9	13	8
III	11	9	7
IV	1	0	3

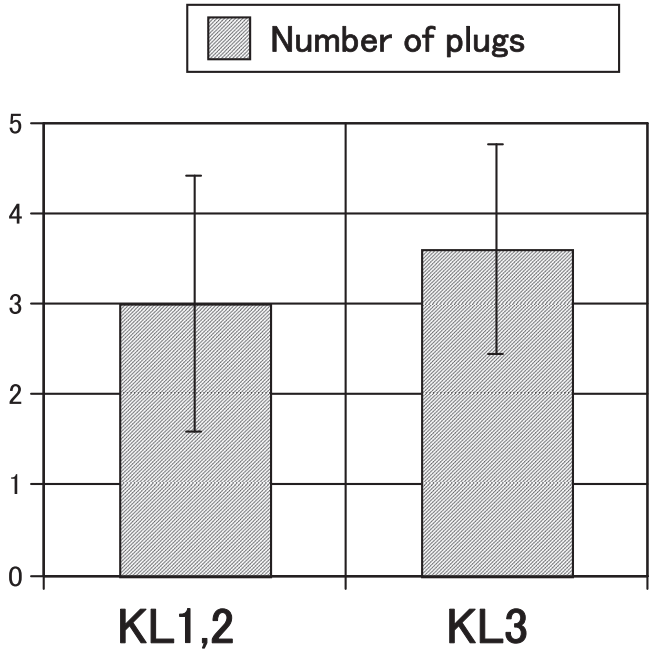

Fig 5. The number of the grafted plugs (mean ± standard deviation). The number of the grafted plugs in patients who had grade 1 or 2 in KL classification at 2 years after AOG tended to be smaller than that in the patients who had grade 3 ($P = .0884$).

involvement and measuring ≤2-4 cm^2. Gomoll[18] noted that a patient age of 35 to 45 years or more is associated with worse outcomes. Moreover, Kim et al.[19] reported that the clinical microfracture scores significantly improved 1 year after surgery. However, the scores deteriorated over time after postoperative 1 year, and the mean values reached preoperative levels at 10 years after operation. Four patients underwent TKA conversion. The mean duration of TKA conversion after microfracture was 7.1 years.[19] In osteochondral allograft transplantation, after age stratification, failures among patients >40 years old were associated with a large defect size when compared with nonfailures.[20]

Table 4. The Ability of Straight Sitting in Japanese Style Among Age Groups, Disease Groups, and Other Subgroups

	Before Surgery	2 Years After Surgery	Follow-up
Age			
60-69 years	3/32 (9.4%)	19/32 (59.4%)	16/28 (57.1%)
70-79 years	2/28 (7.1%)	13/28 (46.4%)	6/21 (28.6%)
Disease groups			
Osteonecrosis	3/36 (8.3%)	20/36 (55.0%)	12/30 (40.0%)
Cartilage injury	2/24 (8.3%)	12/24 (50.0%)	10/19 (52.6%)
Subgroups			
ON in 60s	2/16 (12.5%)	9/16 (56.3%)	7/15 (46.7%)
CI in 60s	1/16 (6.3%)	10/16 (62.5%)	9/13 (69.2%)
ON in 70s	1/20 (5.0%)	11/20 (55.0%)	5/15 (33.3%)
CI in 70s	1/8 (12.5%)	2/8 (25.0%)	1/6 (16.7%)

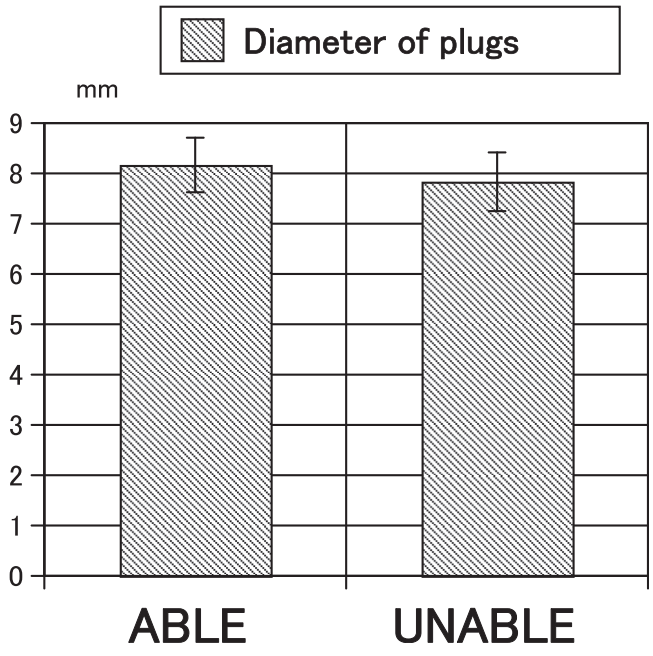

Fig 6. The diameter of the grafted plugs (mean ± standard deviation). The diameter of the grafted plugs in the patients who could sit straight in Japanese style 2 years after AOG was significantly larger than that in the patients who could not sit straight in Japanese style ($P = .0268$)

Kim et al.[21] reported that satisfactory clinical and radiological outcomes were obtained with the use of a gel-type fibrin-matrix autologous chondrocyte implantation (ACI) technique in patients >50 years old with a cartilage knee defect. Histological analysis confirmed that the newly repaired tissue with hyaline cartilage filled the cartilage defect area. Kon et al.[22] reported that a clinical improvement was found in patients >40 years old who, in most cases, benefited from second-generation ACI, with good results lasting at medium-term follow-up. Furthermore, Gobbi et al.[23] proposed that bone marrow–derived mesenchymal stem cells were found to be effective for patients >45 years old and that the outcome was mainly affected by lesion size and not patient age. Although good outcomes can be expected among treated patients >45 years old, outcomes may be comparatively more successful in young patients.[24] In the present study, the clinical AOG outcomes in aged patients are superior to those reported in the literature for microfracture and osteochondral allograft transplantation and may be similar to those of ACI and bone marrow–derived mesenchymal stem cells.

AOG outcomes have been promising with good to excellent results in patients with femoral condylar defects (92%), tibial resurfacing (87%), and patellar or trochlear procedures (74%).[25] Despite a higher rate of preoperative osteoarthritic changes in athletic patients, clinical mosaicplasty outcomes in this group demonstrated a success rate similar to that of less athletic patients.[9] Structural grafts including AOG are a viable treatment option for symptomatic focal osteochondral lesions of the patellofemoral joint in patients 40 years and older, with anticipated improvements in pain and function and maintenance of preoperative activity levels.[26] Although optimal results were still found in younger patients (<30 years), patients >40 years old also appeared to benefit from cartilage lesion treatment, and no significant differences were noted compared with the younger population.[26] Moreover, Robb et al.[12] reported that advanced age is the sole risk factor for failure after AOG and osteochondral allograft transplantation. The results of the present study showed that AOG for patients older than 60 years was not a contraindication. However, the most active patients lowered their activity level whereas the more sedentary patients did not have to adapt their lifestyle.[27] Similarly, the clinical outcomes in the present study became slightly worse if their follow-up period was longer. In particular, the 70s CI group showed these tendencies, which may be due to degeneration caused by old age.

According to the evaluation of the KL grade, significant differences with time after microfracture was noted. Specifically, significant degenerative changes were confirmed 5 years after microfracture.[19] In ACI, 12 of 26 successful knees were radiographically assessed (mean, 5.6 years after surgery), with no significant osteoarthritis progression.[28] The modified magnetic resonance imaging observation of cartilage repair tissue score improved 2 years after fibrin-matrix ACI in patients >50 years old.[21] In AOG, slight or moderate degenerative changes were detected before surgery in 27% of the cases and in 36% of the cases at follow-up (average, 9.6 years).[9] In the present study, the number of patients who were in grade 1 or 2 at 2 years after AOG were significantly higher than those in the preoperative period in the 60s group. Kumagai et al.[29] suggested that AOG is superior to bone marrow stimulation as a concomitant procedure with opening-wedge valgus osteotomy for spontaneous osteonecrosis in the success of cartilage repair. The present study showed that the mean scores were 10.8 points (range 9-12) in the total cases in ICRS cartilage repair assessment during second-look arthroscopy. According to the radiographic and cartilage repair assessment, AOG for patients >60 years old is also a good indication.

Being able to sit straight in Japanese style is still very important in the Japanese lifestyle. Therefore sitting straight in Japanese style was recommended to patients who received AOG for their knee osteochondral diseases. Choy et al.[30] reported the outcome after unicompartmental knee arthroplasty (UKA) for spontaneous knee osteonecrosis. Choy et al.[30] commented about the squatting position and the cross-leg posture

but did not mention about sitting straight in Japanese style. Regarding osteoarthritis, some reports about sitting straight in Japanese style after knee surgery was noted, although osteoarthritis differs from spontaneous osteonecrosis. In addition, all reports were from Japan. Niki et al.[31] reported the ability to sit straight in Japanese style after TKA. In their report, 23 patients (29 knees) of a series of 463 TKA in 341 patients were able to sit straight in Japanese style. Although some reports in Japanese on the rate of the ability to sit straight in Japanese style after UKA was 20% to 30%, no reports in English have been noted concerning UKA. Takeuchi et al.[32] reported that 17 of 24 patients (71%) could sit straight in Japanese style after open-wedge HTO, whereas none of them could do so before surgery. Mukai et al.[33] reported in a Japanese article that 65% of 26 cases were able to sit in Japanese style after AOG. The patients in the article by Mukai et al.[33] underwent only AOG for osteonecrosis of the medial femoral condyle of their knees without malalignment. The factor related to being able to sit in seiza was the recipient area less than 435 mm^2. Tarumi et al.[34] reported the clinical outcomes following HTO combined with AOG for osteonecrosis of the medial femoral condyle. In the study by Tarumi et al.[34] and the present study, the recipient area was not a significant factor related to the ability to sit in seiza. The important factor in the present study was the diameter of the grafted plugs. Tarumi et al.[34] reported that 50% of the patients could sit in seiza after surgery. The present study reported that 53.3% of the patients could sit in seiza 2 years after AOG. These were better than the results of TKA and UKA described above. During high flexion, excessive compressive pressure is generated at all compartments of the knee joints, leading to accelerated cartilage degeneration.[35] However, the present study showed no deterioration in clinical scores of the patients who could sit straight in Japanese style after AOG.

Limitations

This study is not without limitations. The small sample size (57 cases and 60 knees), the shorter mid-term follow-up (81.1 months: range 24-167 months), including the patients with combined operation such as partial meniscectomy, anterior cruciate ligament reconstruction, or lateral release, and an observational study (not a randomized clinical trial) were the most important limitations of the current study.

Conclusion

Even if the patient's operative age was >60 years, the AOG only for their knee osteochondral diseases had good clinical outcomes, including the ability to sit straight in Japanese style.

References

1. Bobic V. Arthroscopic osteochondral autograft transplantation in anterior cruciate ligament reconstruction: A preliminary clinical study. *Knee Surg Sports Traumatol Arthrosc* 1996;3:262-264.
2. Hangody L, Kish G, Karpati Z, Udvarhelyi I, Szigeti I, Bely M. Mosaicplasty for the treatment of articular cartilage defects: Application in clinical practice. *Orthopedics* 1998;21:751-756.
3. Jakob RP, Franz T, Gautier E, Mainil-Varlet P. Autologous osteochondral grafting in the knee: Indication, results, and reflections. *Clin Orthop* 2002;401:170-184.
4. Matsusue Y, Yamamuro T, Hama H. Arthroscopic multiple osteochondral transplantation to the chondral defect in the knee associated with anterior cruciate ligament disruption: A case report. *Arthroscopy* 1993;9:318-321.
5. Nakagawa Y, Matsusue Y, Ikeda N, Asada Y, Nakamura T. Osteochondral grafting and arthroplasty for end-stage osteochondritis dissecans of the capitellum. A case report and review of the literature. *Am J Sport Med* 2001;29:650-655.
6. Yamashita F, Sakakida K, Sufu F, Takai S. The transplantation of an autogenic osteochondral fragment of osteochondral dissecans of the knee. *Clin Orthop* 1985;201:43-50.
7. Nakagawa Y, Matsusue Y, Nakamura T. A novel surgical procedure for osteochondritis dissecans of the lateral femoral condyle: Exchanging osteochondral plugs taken from donor and recipient sites: A case report and review of the literature. *Arthroscopy* 2002;18(1):E5.
8. Nakagawa Y, Matsusue Y, Nakamura T. Osteochondral graft transplantation for steroid-induced osteonecrosis of the femoral condyle. *Lancet* 2003;362:402.
9. Hangody L, Dobos J, Balo E, Panics G, Hangody LR, Berkes I. Clinical experiences with autologous osteochondral mosaicplasty in an athletic population: A 17-year prospective multicenter study. *Am J Sport Med* 2010;38:1125-1133.
10. Solheim E, Hegna J, Oyen J, Harlem T, Strand T. Results at 10 to 14 years after osteochondral autografting (mosaicplasty) in articular cartilage defects in the knee. *Knee* 2013;20:287-290.
11. Brittberg M, Gomoll AH, Canseco JA, Far J, Lind M, Hui J. Cartilage repair in the degenerative ageing knee. *Acta Orthopaedica* 2016;87:(eSuppl 363) 26-38.
12. Robb CA, EI-Sayed C, Matharu GS, Baloch K, Pynsent P. Survival of autologous osteochondral grafts in the knee and factors influencing outcome. *Acta Orthop Belg* 2012;78:643-651.
13. Nakagawa Y, Mukai S, Yabumoto H, Tarumi E, Nakamura T. Serial changes of the cartilage in recipient sites and their mirror sites on second-look imaging after mosaicplasty. *Am J Sports Med* 2016;44:1243-1248.
14. Nakagawa Y, Mukai S, Yamada S, et al. Short-term effects of highly-bioavailable curcumin for treating knee osteoarthritis: A randomized, double-blind, placebo-controlled prospective study. *J Orthop Sci* 2014;19:933-939.
15. Brittberg M, Aglietti A, Gambardella R, et al. ICRS cartilage injury evaluation package. Accessed July 22, 2023. Available at: http://www.cartilage.org/.

16. Okuda M, Omokawa S, Okahashi K, Akahane M, Tanaka Y. Validity and reliability of the Japanese Orthopaedic Association score for osteoarthritic knees. *J Orthop Sci* 2012;17:750-756.
17. Harris JD, Brand JC, Cote MP. Faucrils of pooling. Part 1ett SC, Dhawan A. Research Pearls: The significance of statistics and perils of pooling. Part 1: Clinical versus statistical significance. *Arthroscopy* 2017;33:1102-1112.
18. Gomoll AH. Microfracture and augments. *J Knee Surg* 2012;25:9-15.
19. Kim JK, Vaidya R, Lee SK, et al. Clinical and radiological changes after microfracture of knee chondral lesions in middle-aged Asian patients. *Clin Orthop Surg* 2019;11(39): 282-290.
20. Lee S, Frank RM, Christian DR, Cole BJ. Analysis of defect size and ratio to condylar size with respect to outcomes after isolated osteochondral allograft transplantation. *Am J Sports Med* 2019;47:1601-1612.
21. Kim MK, Park JS, Jeon YM, Jeon YS. Clinical, radiological, and histological outcomes after the fiblin-matrix autologous chondrocyte implantation for chondral lesions of the knee in patients more than 50 years old: A prospective case series with minimum 2-year follow-up. *J Orthop Surg* 2019;28:1-9.
22. Kon E, Filardo G, Condello V, et al. Second-generation autologous chondrocyte implantation: Results in patients older than 40 years. *Am J Sports Med* 2011;39:1668-1675.
23. Gobbi A, Scotti C, Karnatzikos G, Mudhigere A, Cstro M, Peretti GM. One-stage surgery with multipotent stem cells and Hyaluronan-based scaffold for the treatment of full-thickness chondral defects of the knee in patients older than 45 years. *Knee Surg Sports Traumatol Arthrosc* 2017;25: 2494-2501.
24. Gobbi A, Whyte GP. Long-term clinical outcomes of one-stage cartilage repair in the knee with Hyaluronic acid-based scaffold embedded with mesenchymal stem cells sourced from bone marrow aspirate concentrate. *Am J Sports Med* 2019;47:1621-1628.
25. Hangody L, Vasarhelyi G, Hangody LR, et al. Autologous osteochondral grafting-technique and long-term results. *Injury* 2008;39:(Suppl 1) S32-S39.
26. Degen RM, Coleman NW, Tetreault D, et al. Outcomes of patellofemoral osteochondral lesions treated with structural grafts in patients older than 40 years. *Cartilage* 2017;8:255-262.
27. Filardo G, Andriolo L, Sessa A, et al. Age is not a contraindication for cartilage surgery: A critical analysis of standardized outcomes at long-term follow-up. *Am J Sports Med* 2017;45:1822-1828.
28. Ogura T, Bryant T, Mina T. Long-term outcomes of autologous chondrocyte implantation in adolescent patients. *Am J Sports Med* 2017;45:1066-1074.
29. Kumagai K, Akamatsu Y, Kobayashi H, Kusayama Y, Saito T. Mosaic osteochondral autograft transplantation versus bone marrow stimulation technique as a concomitant procedure with opening-wedge high tibial osteotomy for spontaneous osteonecrosis of the medial femoral condyle. *Arthroscopy* 2018;34:233-240.
30. Choy WS, Kim KJ, Lee SK, Yang DS, Kim CM, Park JS. Medial unicompartmental knee arthroplasty in patients with spontaneous osteonecrosis of the knee. *Clin Orthop Surg* 2011;3:279-284.
31. Niki Y, Takeda Y, Udagawa K, Enomoto H, Toyama Y, Suda Y. Is greater than 145° of deep knee flexion under weight-bearing conditions safe after total knee arthroplasty? A fluoroscopic analysis of Japanese-style deep knee flexion. *Bone Joint J* 2013;95B(6):782-787.
32. Takeuchi R, Umemoto Y, Aratake M, et al. A mid-term comparison of open wedge high tibial osteotomy vs unicompartmental knee arthroplasty for medial compartment osteoarthritis of the knee. *J Orthop Surg Res* 2010;5:65.
33. Mukai S, Nakagawa Y, Matsuoka M, Tanaka Y, Nakamura T. The clinical outcome of mosaicplasty for spontaneous osteonecrosis of the knee. The factor of the ability of sitting straight in Japanese style [in Japanese]. *JOSKAS* 2014;39:937-942.
34. Tarumi E, Nakagawa Y, Mukai S, Yabumoto H, Nakamura T. The clinical outcomes and the ability to sit straight in the Japanese style following high tibial osteotomy combined with osteochondral autologous transfer for osteonecrosis of the medial femoral condyle. *J Orthop Sci* 2019;24:136-141.
35. Thambyah A, Goh JC, De SD. Contact stresses in the knee joint tact stresses in the knee joint in deep flexion. *Med Eng Phys* 2005;27:329-335.