Knee Surgery, Sports Traumatology, Arthroscopy (2019) 27:189–196
https://doi.org/10.1007/s00167-018-5024-1

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Pullout fixation for medial meniscus posterior root tears: clinical results were not age-dependent, but osteoarthritis progressed

Kyu Sung Chung[1] · Jeong Ku Ha[1] · Ho Jong Ra[2] · Han Sung Lee[3] · Dhong Won Lee[4] · Jung Ho Park[4] · Du Han Kim[4] · Jin Goo Kim[4]

Received: 2 August 2017 / Accepted: 12 June 2018 / Published online: 13 July 2018

Abstract

Purpose This study investigated the outcomes of pullout fixation for medial meniscus posterior root tears (MMPRTs) in patients ≤ 60 years old versus patients > 60 years old. It was hypothesized that older patients would demonstrate results comparable with those of younger patients.

Methods Patients with pullout fixation who were followed-up for more than 5 years were included. Patients were categorized into two groups based on age (group A, ≤ 60 years; group B, > 60 years). The Lysholm score, Kellgren–Lawrence (K–L, 0/1/2/3/4) grade, and medial joint space width were evaluated retrospectively. Preoperative results were compared with the final results in each group, which were compared between groups.

Results Twenty-five patients in group A (mean age, 54.7 ± 3.8 years) and 22 patients in group B (mean age, 65.6 ± 4.4 years) were recruited. The mean follow-up duration was 70.9 months. The Lysholm score (group A, 53.0 ± 9.1 to 86.0 ± 12.1, $P < 0.001$; group B, 51.1 ± 7.1 to 82.9 ± 9.7, $P < 0.001$) improved significantly. However, the joint space width (group A, 4.7 ± 1.1 to 3.9 ± 1.1 mm, $P < 0.001$; group B, 4.7 ± 0.9 to 3.8 ± 0.9 mm, $P < 0.001$) and K–L grade (group A, 3/17/5/0/0 to 0/7/11/7/0, $P < 0.001$; group B, 2/14/6/0/0 to 0/3/14/5/0, $P < 0.001$) worsened significantly. No significant differences between groups were observed in final outcomes, including Lysholm score (n.s.), K–L grade (n.s.), and joint space narrowing (n.s.). No case with operation failure that require total knee arthroplasty was not observed.

Conclusion MMPRT fixation did not prevent the progression of arthrosis completely. However, clinical outcomes were not age-dependent. Thus, age may not be a critical factor to consider when applying fixation.

Level of evidence Retrospective case–control study; Level of evidence, IV.

Keywords Medial meniscus · Posterior root tear · Pullout fixation · Age

Introduction

Medial meniscus posterior root tears (MMPRTs) disrupt the continuity of the circumferential fibers, leading to loss of hoop tension, loss of load sharing ability, and unacceptable peak pressures [2]. The pathological loads lead to degenerative arthritic changes in the knee joint [1, 5]. Fixation for MMPRT can restore meniscal hoop tension and slow the progression of arthritis [10, 13, 18]. Encouraging results from MMPRT fixation over the last decade has increased interest in this procedure.

MMPRT is common in middle-aged or older people due to their lifestyle behaviors, including frequent squatting and sitting on the floor with the legs folded [3]. Their lifestyle may lead to an increased risk of posterior meniscal segment impingement, and the resultant degenerated posterior

✉ Jin Goo Kim
boram107@hanmail.net

[1] Department of Orthopedic Surgery and Sports Medical Center and Sports Medical Research Institute, Seoul Paik Hospital, College of Medicine, Inje University, Seoul, South Korea

[2] Department of Orthopedic Surgery, Gangneung Asan Hospital, College of Medicine, Ulsan University, Gangneung, South Korea

[3] Department of Orthopedic Surgery, Hanil General Hospital, Seoul, South Korea

[4] Department of Orthopedic Surgery and Sports Medical Center, KonKuk University Medical Center, 120-1 Neungdong-ro, Kwangjin-gu, Seoul, South Korea

horn may result in MMPRT [3]. Based on previous literature, the mean age of MMPRT patients is approximately 50–60 years [6]. The primary aim of management in patients with MMPRT is the prevention of arthrosis and this goal remains the same in the elderly. However, there is still concern in terms of progression of osteoarthritis or prevention of osteoarthritis following root repair for MMPRTs. Especially for medial root tears, typically more common in the elderly, it might be helpful to estimate clinical consequences and treatment strategies for MMPRT for elderly patients. In LaPrade et al.'s study showing clinical outcomes among age groups after root repair, patients < 50 years old had outcomes similar to those of patients ≥ 50 years old [17]. However, this study was based on short-term follow-up results and the cut-off age was relatively young. There is little evidence concerning the midterm outcomes in the elderly population, especially with regard to progression of arthrosis. Performing MMPRT fixation in elderly patients remains potentially controversial, and surgeons may hesitate to perform surgical fixation in patients with advanced age due to lack of confidence in the ability to achieve satisfactory outcomes or concern of non-healing. Instead, they may perform conservative treatment, meniscectomy, or arthroplasty for MMPRT.

Therefore, the current study aimed to compare midterm clinical and radiological outcomes in patients between 60 years of age or less versus patients over 60 years of age, with a minimum of 5 years follow-up after MMPRT pullout fixation. The age cut-off was decided based on the mean age of patients with MMPRT, which is approximately 55–60 years [6]; thus, patients were categorized into two groups: group A (≤ 60 years) and group B (> 60 years). It was hypothesized that MMPRT fixation could prevent progression of arthrosis and patients > 60 years old would demonstrate comparable midterm results following fixation in comparison to patients ≤ 60 years old.

Materials and methods

This study was retrospective in nature. All medical records were reviewed retrospectively to obtain patients' demographic and clinical characteristics from a database of our institution. MMPRT was defined as a complete radial tear within 9 mm of the posterior bony attachment of the medial meniscus [16]. MMPRT was confirmed preoperatively using 1.5-T magnetic resonance imaging (MRI; Intera Achieva; Philips, Eindhoven, the Netherlands) when two or more of the following signs appeared on MRI: the absence of an identifiable meniscus or high signal that replaced the normal dark meniscal signal (i.e., the ghost sign) in the sagittal view, a vertical linear defect at the meniscal root in the coronal view, or a radial linear defect at the posterior insertion in the axial view [20].

Among patients with MMPRT diagnosed using MRI between August 2005 and May 2010, patients with persistent pain who underwent surgery were recruited. The inclusion criterion was patients undergoing arthroscopic pullout fixation. Surgical fixation was performed in patients with: (a) a suitable meniscal condition for fixation without complex root tears or degenerative changes and (b) a Kellgren–Lawrence (K–L) grade two or less. The exclusion criteria were: (a) patients undergoing meniscectomy in MMPRT, (b) patients who underwent pullout fixation combined with a high tibial osteotomy, (c) patients who underwent pullout fixation with a concomitant ligament injury, and (d) patients with pullout fixation whose follow-up was less than 5 years.

Preoperative MRI was performed in all patients; follow-up MRI was performed at 1 year postoperatively with permission from the patients.

Surgical technique for pullout fixation

A single surgeon (JGK) performed all surgical procedures. The transtibial pullout fixation technique with simple sutures, as described previously, was used for MMPRT fixation [8, 10]. First, debridement was performed to identify the torn edge of the meniscus and the bony bed was prepared using a curette. A crescent-shaped suture hook (Linvatec, Largo, FL, USA), loaded with no.1 polydioxanone, was inserted at a point 3–5 mm medial to the torn edge of the detached portion of the meniscus. The polydioxanone was advanced through the meniscus to form a simple vertical suture. One or two additional strands were positioned 3–5 mm apart, using the same technique. Thereafter, a tibial tunnel was created using an anterior cruciate ligament reconstruction tibial tunnel guide (Linvatec; Largo, FL, USA), with its tip in contact with the attachment site of the posterior root. The ends of the sutures were pulled through the tibial tunnel, followed by meniscus reduction and stabilization. The suture ends were tied over a polypropylene button (Ethicon, Somerville, NJ, USA) on the anteromedial cortex of the proximal tibia.

Postoperative rehabilitation

Toe-touch weight bearing with the use of crutches and a knee brace locked in extension was required for 3 weeks postoperatively. Progressive knee range-of-motion exercises (ROM) using a continuous passive motion machine and isometric exercise were initiated at 2 or 3 days postoperatively. Crutches were continued and the motion allowed in the brace was progressively increased starting at 3 weeks. The brace was discontinued and full weight bearing and closed chain kinetic exercises were initiated at 6 weeks postoperatively. Patients were asked to permanently avoid deep flexion to decrease the risk of re-injury to the posterior meniscus root.

Age distribution

The patients were categorized into two groups based on their age: patients 60 years and younger (≤ 60 years; group A) and patients greater than 60 years (> 60 years; group B).

Clinical outcomes

The Lysholm score was assessed preoperatively and at final follow-up. The Lysholm score was evaluated by one of the authors (JKH) not involved in the surgery. Preoperative results were compared with the final results within each group and the final results were compared between groups.

Radiological outcomes

The Rosenberg 45° posteroanterior standing view was used to assess the Kellgren–Lawrence (K–L) arthritis grade and to measure the medial joint space preoperatively and at final follow-up [23]. The K–L grade (0/1/2/3/4) was defined as follows: grade 0, no degenerative change; grade 1, questionable osteophytes and no joint space narrowing; grade 2, definite osteophytes with possible joint space narrowing; grade 3, definite joint space narrowing with moderate multiple osteophytes and some sclerosis; grade 4, severe joint space narrowing with cysts, osteophytes, and sclerosis [12]. The medial joint space was measured from the center of the medial femoral condyle to the center of the medial tibial plateau using a picture archiving and communication system (PACS, Marotech, Seoul, Korea). The preoperative K–L grade and medial joint space results were compared with the final results within each group and the final results were compared between groups. More than 2 mm of narrowing and K–L grade progression of two grades or more between the preoperative and postoperative measurements were defined as major joint space narrowing and major K–L grade progression, respectively [19]. The percentage of patients with major joint space narrowing and major K–L grade progression was compared between groups.

Extrusion of the medial meniscus (mm) was defined as the amount of meniscus displacement from the superomedial aspect of the tibial plateau to the periphery of the meniscal body at the level of the medial collateral ligament (MCL) in the coronal plane [21]. Difference of meniscus extrusion was assessed by MRI performed at preoperatively and at 1 year postoperatively with permission from the patients. The healing status was classified as complete healing (confirmed continuity in all three planes: sagittal, coronal, and axial), partial healing (loss of continuity in any one or two planes), or non-healing (loss of continuity in all planes) by MRI at 1 year postoperatively [13]. The difference in meniscus extrusion and healing status were compared between groups.

Radiographic images were examined independently by two authors blinded to the procedures used in consultation with a single experienced musculoskeletal radiologist. All radiographic measurements were documented three times at two-week intervals using PACS; the averages of these measurements were used in our analysis.

This study protocol was approved by the institutional review board at Seoul Paik Hospital of Inje University (no. IIT-2016-241). All patients provided written informed consent.

Statistical analysis

Statistical analyses were performed using SPSS software (ver. 20.0 for Windows; SPSS Inc., Chicago, IL, USA). Statistical significance level was set at a P value below 0.05. The Mann–Whitney test was used to compare continuous variables between groups, and other numerical values. The Wilcoxon signed rank test was used to compare the preoperative results and final results within each group. The Chi square test was used to compare categorical data: the Fisher's exact test was used if more than 20% of the expected frequencies were greater than 5.

Intraclass correlation coefficients (ICCs) were calculated to determine the interobserver and intraobserver reliability of differences in radiological outcome measurements. All measurements that allowed one decimal value were documented three times at two-week intervals to assess intraobserver reliability. The averages of these measurements were used in analysis. Two observers measured each radiological outcome independently, and this was used to assess interobserver reliability.

The statistical power was calculated retrospectively. This study had a power of 99% for the detection of the rate of K–L grade progression rate from pre- to post-operation in each group at a significance level of 0.05, using post hoc analys. However, the power for the detection of a difference in K–L grade progression rate between the two groups was 40%.

Results

Table 1 shows the age distribution of patients included versus that of those excluded from the study. In total, 47 patients were included: 25 patients in group A and 22 patients in group B (Fig. 1). Mean age of groups A and B was 54.7 ± 3.8 and 65.6 ± 4.4 years, respectively, which was statistically different between groups ($P < 0.001$). With the exception of age, there was no significant difference between groups A and B in terms of preoperative demographic data

Table 1 Comparing age distribution of unselected with selected patients

	Pullout fixation ($n=47$)	Meniscectomy ($n=23$)	Pullout fixation with multiple ligament injuries ($n=8$)	Pullout fixation with high tibial osteotomy ($n=5$)	Follow-up loss ($n=8$)
Age	59.8 ± 6.9	58.9 ± 6.9	28.4 ± 9.8	59.6 ± 3.8	58.4 ± 5.5
P value[a] (vs pull-out fixation)		n.s.	< 0.001	n.s.	n.s.

ns not significant

Values are expressed as mean ± standard deviation

[a]Mann Whitney test

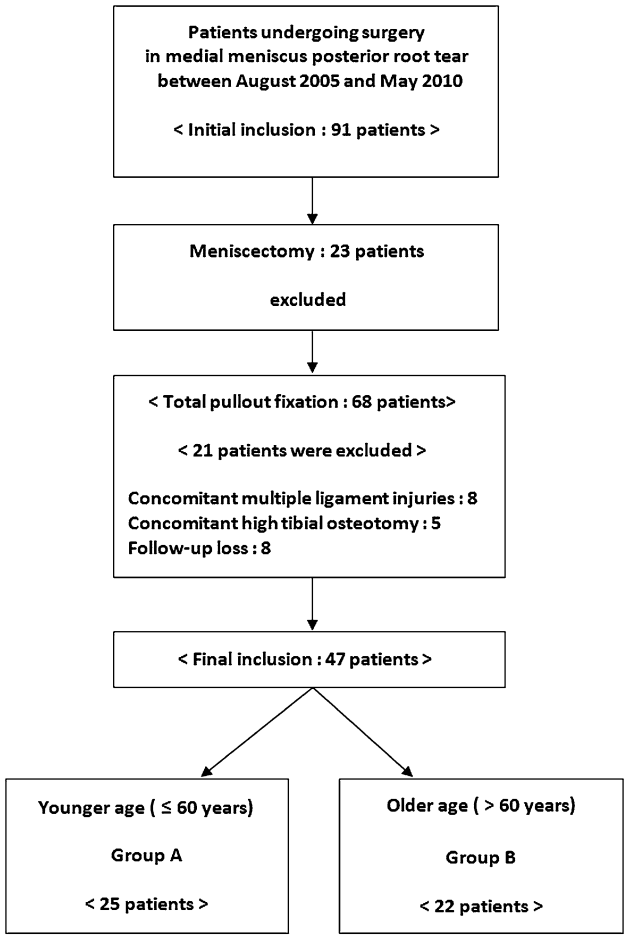

Fig. 1 Flow chart of included participants

and patients' characteristics (Table 2). Mean follow-up duration of groups A and B was 71.3 ± 14.1 and 72.5 ± 24.1 months, respectively.

Clinical Outcomes

There were significant improvements in the Lysholm score in groups A and B between preoperative and final assessment ($P < 0.001$, Table 3). Comparison of the final Lysholm scores (group A, 86.0 ± 12.1; group B, 82.9 ± 9.7; *n.s.*) between groups showed that clinical scores of group A were not significantly different from those of group B (Table 4).

Radiological outcomes

Table 3 shows the comparison of preoperative versus final results in each group. In group A, medial joint space width decreased significantly and K–L grade worsened significantly at final follow-up ($P < 0.001$). Similarly, in group B, medial joint space width decreased significantly and K–L grade worsened significantly at final follow-up ($P < 0.001$).

Table 4 shows the comparison of data from group A versus group B at final follow-up. No significant differences were observed between groups in terms of progression of medial joint space narrowing (*n.s.*), rate of major joint space narrowing (*n.s.*), rate of K–L grade progression (*n.s.*), and rate of major K–L grade progression (*n.s.*).

One year postoperative follow-up MRI was performed in 43 patients, including 24 patients of group A and 19 patients of group B. In terms of meniscal healing, no difference was observed between groups A and B (Table 4). In terms of meniscal extrusion, among these 43 patients, in group A, meniscal extrusion changed from 4.0 ± 1.2 mm preoperatively to 4.4 ± 1.5 mm at final follow-up (*n.s.*). In group B, meniscal extrusion changed from 3.6 ± 0.9 mm preoperatively to 4.2 ± 1.6 mm at final follow-up (*n.s.*). However, no significant differences were observed in postoperative extrusion values (*n.s.*) and difference between pre and postoperative values (*n.s.*; Table 4). Seventeen patients with decreased extrusion had significantly lower rate of K–L grade progression ($n=9$, 53%) in comparison to 26 patients with increased extrusion ($n=23$, 88%) based on Fisher's exact test ($P=0.014$).

All ICCs ranged from 0.90 to 0.96, which indicated very good reliability (ICCs > 0.9) in this study [24].

There was no case with operation failure that require total knee arthroplasty (TKA) or progression to K–L grade 4.

Table 2 Preoperative demographics, clinical scores and study findings

Preoperative characteristics ($n=47$)	Age ≤ 60 years (Group A, $n=25$)	Age > 60 years (Group B, $n=22$)	P value[a]
Demography			
Age, yr	54.7 ± 3.8	65.6 ± 4.4	< 0.001[c]
Sex, male/female	3/22	2/20	n.s.[d]
Body mass index, kg/m^2	26.2 ± 2.3	25.1 ± 2.6	n.s.[c]
Follow-up period, mo	71.3 ± 14.1	72.5 ± 24.1	n.s.[c]
Clinical scores			
Lysholm score	53.0 ± 9.1	51.1 ± 7.1	n.s.[c]
IKDC subjective knee form	41.2 ± 7.4	39.4 ± 6.5	n.s.[c]
Radiologic status			
Medial joint space, mm	4.7 ± 1.1	4.7 ± 0.9	n.s.[c]
Kellgren–Lawrence grade, 0/1/2/3/4	3/17/5/0/0	2/14/6/0/0	n.s.[d]
Cartilage arthrosis grade, 0/1/2/3/4	3/5/8/9/0	4/4/8/6/0	n.s.[d]

Values are expressed as mean ± standard deviation

ns not significant

[a]The p values were calculated with comparison Group A to B

[b]The p values were calculated with comparison Group A to C

[c]Mann Whitney test

[d]Fisher's exact test

[e]Chi-square test

Table 3 Preoperative and postoperative clinical outcomes and study findings

	Age ≤ 60 years (Group A, $n=25$)			Age > 60 years (Group B, $n=22$)		
	Preoperation	Final follow-up	P value	Preoperation	Final follow-up	P value
Lysholm score	53.0 ± 9.1	86.0 ± 12.1	< 0.001[a]	51.1 ± 7.1	82.9 ± 9.7	< 0.001[a]
IKDC subjective knee form	41.2 ± 7.4	75.7 ± 11.9	< 0.001[a]	39.4 ± 6.5	72.6 ± 8.3	< 0.001[a]
Width of medial joint space, mm	4.7 ± 1.1	3.9 ± 1.1	< 0.001[a]	4.7 ± 0.9	3.8 ± 0.9	< 0.001[a]
Kellgren–Lawrence grade, 0/1/2/3/4	3/17/5/0/0	0/7/11/7/0	< 0.001[b]	2/14/6/0/0	0/3/14/5/0	< 0.001[b]

Values are expressed as mean ± standard deviation

[a]Wilcoxon signed rank test

[b]Fisher's exact test

Discussion

The most important finding of this study was that midterm outcomes of older patients > 60 years old were not inferior to those of patients ≤ 60 years old after pullout fixation for MMPRT. Pullout fixation was associated with significantly improved clinical scores at final follow-up compared with preoperative scores, regardless of age. In terms of radiological outcomes, no difference was observed in narrowing of the medial joint space width and K–L grade progression between groups. Thus, clinical outcomes following MMPRT fixation were not age-dependent. However, K–L grade and joint space width worsened significantly in both groups. MMPRT fixation did not prevent arthritic changes completely at midterm follow-up, regardless of age.

To our knowledge, the method that theoretically has the best chance of restoration of hoop tension is surgical fixation for MMPRT. Krych et al. reported that 31% of patients with MMPRT underwent subsequent TKA at a mean of 30 months after conservative treatment [15]. Also, 54% of MMPRT patients underwent subsequent TKA at a mean of 54.3 months after meniscectomy [14]. On the other hand, pullout fixation was superior to partial meniscectomy in terms of clinical and radiologic outcomes and survival with at least 5 years follow-up [10]. According to systematic reviews, arthroscopic fixation showed favorable short-term outcomes for MMPRT [6, 11].

Based on the results of present study, however, MMPRT fixation did not prevent arthritic changes completely, regardless of age, at minimum 5-year follow-up. The K–L grade and joint space width worsened significantly in both groups.

Table 4 Postoperative clinical and radiological outcomes between groups

Postoperative outcomes	Age ≤ 60 years (Group A, $n=25$)	Age > 60 years (Group B, $n=22$)	P value[a]
Lysholm score	86.0 ± 12.1	82.9 ± 9.7	n.s.[c]
IKDC subjective knee form	75.7 ± 11.9	72.6 ± 8.3	n.s.[c]
Width of medial joint space, mm	3.9 ± 1.1	3.8 ± 0.9	n.s.[c]
Progression of joint space narrowing, mm	0.9 ± 0.8	0.9 ± 0.6	n.s.[c]
Progression of joint space narrowing ≥ 2 mm, *n* (%) (Major joint space narrowing)	2 (8%)	0 (0%)	n.s.[d]
Kellgren–Lawrence grade, 0/1/2/3/4, *n*	0/7/11/7/0	0/3/14/5/0	n.s.[d]
Progression of Kellgren–Lawrence grade, *n* (%)	17 (68%)	18 (82%)	n.s.[e]
Progression of Kellgren–Lawrence ≥ 2 grades, *n* (%) (Major K–L grade progression)	5 (20%)	2 (9%)	n.s.[d]
Postoperative meniscus extrusion[f], mm	4.4 ± 1.5	4.2 ± 1.6	n.s.[c]
Difference values of meniscus extrusion (pre–post)[f], mm	− 0.4 ± 1.3	− 0.6 ± 1.6	n.s.[c]
Healing status of meniscus (complete/partial/none)[f], *n*	12/12/0	10/9/0	n.s.[f]

ns not significant

Values are expressed as mean ± standard deviation

[a]The *p* values were calculated with comparison Group A–B

[b]The *p* values were calculated with comparison Group A–C

[c]Mann Whitney test

[d]Fisher exact test

[e]Chi-square test

[f]The value was taken from magnetic resonance imaging checked at 1 year postoperatively with permission from the patients. Total included number of patients was 43 (24 of group A, 19 of group B)

In total, 74% ($n=35$) of 47 included patients showed progression of K–L grade and worsened medial joint space width, with decrease of approximately 1 mm. These are unexpected results following MMPRT fixation.

A meta-analysis on the outcomes of MMPRT fixation [6] showed no change in meniscus extrusion, which is associated with progression of arthrosis [9]. In the present study, meniscal extrusion was not reduced after fixation, regardless of age. Patients with decreased extrusion had significantly less risk of arthritis progression in comparison to patient with increased extrusion. Thus, reducing extrusion as much as possible is one of the main goals of the surgery.

There is still concern in terms of progression of osteoarthritis or prevention of osteoarthritis following root repair for MMPRT. Radiologic arthritic changes should be the focus, in particular midterm results, rather than short term, because the primary aim of root repair is to prevent arthritic progression. Especially for medial root tears, typically more common in the elderly, the midterm results might be helpful to estimate clinical consequences and treatment strategies. In the future, well-organized prospective studies with long-term follow-up are needed.

In the present study, the age cut-off was decided based on the mean age of patients with MMPRT. The mean age of patients with MMPRT is approximately 55–60 according to preveious report [6], and the median age of our study populations was 60 years old. Thus, in this study, patients were categorized into two groups; patients > 60 and ≤ 60 years old. The authors assumed that age itself may not be a critical factor when surgeons decide to perform surgical fixation for MMPRT. This is the primary reason why we compared outcomes between older and younger patients following MMPRT fixation.

To our knowledge, there have been few studies investigating the correlation between age and midterm outcomes following MMPRT fixation. LaPrade et al. reported that patients < 50 years old had outcomes similar to those of patients ≥ 50 years old after root repair [17]. This is similar to the results of the current study. However, that study was based on short-term follow-up (mean 2.5 years) and the cut-off value for age was relatively younger. Chung et al. reported that older age was related to poorer prognosis, which led to unfavorable clinical score by correlation coefficient analysis [7].

However, we could not identify a cut-off value for the upper age limit at which to expect favorable results with MMPRT fixation; this is due to the fact that the number of patients included in the analysis was small, and the overall results of patients > 60 years old were not significantly different in comparison to those of patients ≤ 60 years old. Additionally, in the present study, the outcomes of much older patients (≥ 70 years old) were satisfactory, and none of them progressed to end-stage arthritis, although final outcomes were not described and statistical comparison

was not performed due to limited number of patients in this group.

There are several strengths of this study. First, the current study analyzed the effectiveness of MMPRT fixation in different age groups. Second, our results were based on midterm follow-up, with analysis of progression of arthritis.

This study has several limitations. First, this study was a non-randomized retrospective analysis without a pre-established protocol and there is no standardization of variables, which makes comparisons less reliable. Also, this study was based on results with low quality cohort and no control group, such as a meniscectomy or conservative treatment group. Thus, there may be a selection bias. Second, it was not sufficient to support the evidence using the difference of the K–L grade progression rate between two groups, although adequate power was achieved in comparing the pre- and postoperative K–L grade progression rate in each group. Thus, beta or type II error could not be ruled out because of the small sample size and low power. Third, the actual restoration of hoop tension and the healing status of the fixed root were not assessed because second-look arthroscopy [4, 22] was not performed. Fourth, follow-up MRI was evaluated at 1 year postoperative; thus, results of meniscal extrusion were based on a short observation time. One year follow-up MRI was not performed in some patients, because they refused due to economic reasons. Also, MRI was not performed at 5-year follow-up due to economic considerations; thus, the actual status of meniscal extrusion or healing at final follow-up is unknown. In the future, long-term prospective comparative studies with larger populations of elderly and younger participants are needed.

Based on the results of this study, MMPRT fixation did not prevent arthritic changes completely. However, clinical outcomes were not age-dependent; thus, it may not be desirable to determine MMPRT fixation based on the patient's age, especially in the elderly population. This is the clinical relevance of the present study.

Conclusion

MMPRT fixation did not prevent the progression of arthrosis completely. However, clinical outcomes were not age-dependent. Thus, age may not be a critical factor to consider when applying fixation.

Funding All authors have no financial interests, activities, relationships, and affiliations to disclose.

Compliance with ethical standards

Conflict of interest All authors have no potential conflict of interest.

Ethical approval Ethical approval was obtained from the institutional review board of our hospital district (IRB no. 2013-06-027-002).

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