# Effect of Meniscal Tear Patterns and Preoperative Cartilage Status on Joint Space Width After Medial Opening-Wedge High Tibial Osteotomy

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**Background:** Medial opening-wedge high tibial osteotomy (MOWHTO) is performed to treat young adults with medial compartment knee osteoarthritis associated with varus deformity. However, factors influencing joint space width (JSW) vary according to the type of medial meniscal tear and have not yet been completely elucidated.

**Purpose:** To examine changes in JSW according to the type of medial meniscal tear after MOWHTO and analyze the influencing factors.

**Study Design:** Cohort study; Level of evidence, 3.

**Methods:** This study was conducted on 134 patients who underwent MOWHTO for medial osteoarthritis and were followed up for >2 years. The patients were classified into 3 groups based on medial meniscal status: intact, nonroot tear, and root tear. The authors then measured the JSW preoperatively and at 3 months, 6 months, 1 year, and >2 years postoperatively; analyzed whether the change in JSW varied according to meniscal status; and determined the association of these changes with the preoperative cartilage grade of the medial femoral condyle (MFC) and medial tibial plateau (MTP). International Knee Documentation Committee (IKDC) scores were used to evaluate clinical function.

**Results:** Of the 134 patients, the medial meniscus was intact in 29 patients, a nonroot tear was observed in 58 patients, and a root tear was observed in 47 patients. Postoperatively, JSW increased for all groups, but the timing of the increase varied between the groups ($P < .001$). JSW increased the most 6 months postoperatively in the intact group and 3 months postoperatively in the nonroot tear and root tear groups ($P < .001$). Additionally, the increase in JSW was the greatest in the root tear group. Preoperatively, MFC and MTP cartilage status differed among the groups; MTP status did not affect the JSW, but MFC status did ($P < .001$). The IKDC score increased from the preoperative to postoperative time point in all groups, but there was no significant difference between groups.

**Conclusion:** The authors observed that the amount and timing of increase in JSW were dependent on the pattern of medial meniscal tear observed when MOWHTO was performed. In addition, the cartilage grade of MFC before surgery was associated with changes in JSW. The IKDC score was not significantly different between groups. However, a longer follow-up period is needed to analyze the correlation with the meniscal tear pattern and JSW.

**Keywords:** joint space width; high tibial osteotomy; medial meniscal tear; preoperative cartilage status

Medial opening-wedge high tibial osteotomy (MOWHTO) is a surgical treatment option widely used for young and active patients who have medial compartment osteoarthritis of the knee joint causing varus deformity.[5,13,16,32] This surgery can help relieve the patient's pain and delay the progression of osteoarthritis, thereby delaying the timing of replacement arthroplasty.[28] MOWHTO is a simple surgical technique that is more accurate and can be performed without the risk of damaging the peroneal nerve compared with the lower accuracy and higher risks associated with closing-wedge high tibial osteotomy (HTO). Additionally, MOWHTO use can avoid peroneal fracture without shortening the length of the lower limb.[24]

The American Journal of Sports Medicine
2024;52(6):1535–1542
DOI: 10.1177/03635465241239327

Medial meniscal tears can be classified into several types depending on the pattern of tear, and a root tear is known to accelerate knee osteoarthritis.[12,30] Good outcomes have been reported using MOWHTO, which is performed to treat varus alignment and root tears of the medial meniscus.[29] A varus alignment of >4° to 5° before surgery is considered an indication for HTO.[18,19]

Changes in joint space width (JSW) as well as movement of the weightbearing axis occur after HTO. An increase in JSW allows us to analyze the healing of the knee joint cartilage indirectly as JSW is an indirect indication of the joint cartilage state and a predictive factor for evaluating the severity of arthritis.[22,25] There are several reports regarding changes in JSW.[26,31,39] In 2017, van der Woude et al[39] reported that JSW increased from 2.0 ± 1.2 mm preoperatively to 2.4 ± 1.3 mm at 1 year after HTO. However, Park et al[31] observed changes in JSW at different times, including preoperatively, postoperatively (3 months, 6 months, 1 year, and >2 years), and at the final follow-up, and reported that the change in JSW was most significant at 3 months postoperatively and JSW remained constant up to 2 years postoperatively. According to a report by Lee et al,[26] after MOWHTO, the medial JSW increased at 3 months postoperatively, whereas the lateral JSW decreased immediately. Accordingly, the specific time at which JSW changes after HTO is debatable.

To the best of our knowledge, information on the timing of changes in JSW after MOWHTO and the factors affecting them is insufficient. In addition, most patients with medial osteoarthritis in their knee joints have a medial meniscal tear, which is related to medial osteoarthritis,[9] but the analysis of changes in JSW after HTO in patients with a medial meniscal tear has not been sufficiently performed. We hypothesized that the change in JSW would be significant when a medial meniscal tear was accompanied by a root tear, and thus we aimed to analyze JSW by dividing patients who underwent HTO into different groups based on the presence and type of a medial meniscal tear. We examined the association of medial compartment osteoarthritis with the pattern of a medial meniscal tear and the cartilage status and analyzed the relationships among various preoperative and postoperative factors.

## METHODS

### Patients and Clinical Assessment

This study was approved by our institutional review board (No. 05-2023-121), and written informed consent was obtained from all patients. This study is a retrospective study, but the data were collected and analyzed prospectively. The inclusion criteria were patients who underwent MOWHTO for medial osteoarthritis between 2016 and 2020 and were followed up for a minimum of 2 years after surgery. Patients who underwent any other knee surgery before this surgery, those who underwent revision, and those whose preoperative and postoperative radiographs were insufficient for analysis were excluded.

The indication for surgery was patients with medial compartment osteoarthritis (observed using long-standing hip-knee-ankle images) and an intact lateral compartment, with persistent symptoms despite receiving continuous nonoperative treatment for >3 months. Preoperative and postoperative alignments, the medial proximal tibial angle, the lateral distal femoral angle, and the joint line convergence angle were measured using long-standing hip-knee-ankle radiographs.

Age, sex, follow-up period, side, and body mass index were determined from the patients' medical records. In addition, according to the presence or absence of a meniscal tear (as observed in the intraoperative arthroscopy), the patients without a tear were classified into the intact group, and the patients with a tear were categorized into the nonroot tear and degenerative root tear groups.[17,21]

The International Knee Documentation Committee (IKDC) score was used to evaluate clinical function in all patients.[6,15] Clinical outcomes were assessed preoperatively, at 1 year postoperatively, and at the final follow-up visit. The clinical scores were analyzed at different time points for each group. A physician assistant who was blinded to this study calculated the scores.

### JSW and Cartilage Status Analysis

Evaluation of JSW progression was performed using anteroposterior radiographs with bilateral weightbearing.

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Submitted August 24, 2023; accepted January 24, 2024.

One or more of the authors has declared the following potential conflict of interest or source of funding: This research was supported by a grant of the Korea Health Technology R&D Project through the Korea Health Industry Development Institute (KHIDI), funded by the Ministry of Health & Welfare, Republic of Korea (grant number: HI19C1085) and by a 2023 research grant from Pusan National University Yangsan Hospital. AOSSM checks author disclosures against the Open Payments Database (OPD). AOSSM has not conducted an independent investigation on the OPD and disclaims any liability or responsibility relating thereto.

These radiographs were obtained preoperatively and at 3 months, 6 months, 1 year, and 2 years postoperatively. To ensure accuracy and minimize measurement error, all images complied with a standardized protocol and were meticulously performed by a skilled technician.[10,25] The radiographs, sized at 17 × 17 inches (43.2 × 43.2 cm), were acquired with the beam positioned to start from the center of both knees, at a distance of 52 inches (132.1 cm).

The values of JSW were measured by 2 orthopaedic surgeons (T.W.K. and S.-M.L.) with >10 years of experience and processed using a digital caliper (PACS [picture archiving and communication system] M6; INFINITT Health Care). The JSW values were measured at the center of the medial compartment using the midpoint method,[7,33] and the measured values at each time point for the different groups were compared. Moreover, to analyze the radiographic factors, the medial proximal tibial angle, which is the angle between the tibial mechanical axis and the articular surface of the proximal tibia, and the joint line convergence angle were measured.[2,8]

For all patients, cartilage grades of the medial femoral condyle (MFC) and medial tibial plateau (MTP) were determined through arthroscopic knee examination using the modified Outerbridge classification system[37] and recorded immediately after surgery. In addition, maximum cartilage degeneration was considered to represent the overall condition of the femoral and tibial sides.[26] Moreover, the patients were classified into 3 groups depending on the meniscal tear pattern observed while performing the surgical procedure, including those with the meniscus intact, those with a root tear, and those with no root tear. A meniscus root tear was defined as a radial tear within 1 cm from the posterior root attachment of the medial meniscus.[18,19,21] Subsequently, the changes in JSW were analyzed postoperatively at different time points according to group, and we analyzed the difference between the preoperative JSW and the final JSW by group to determine whether there was a difference in the amounts of change in JSW. Addionally, we analyzed preoperative cartilage grade associated with change in JSW.

## Surgical Technique and Postoperative Rehabilitation

Patients were operated on under general, spinal, or epidural anesthesia depending on their condition. All surgeries were preplanned.[23,26,38] The surgeries were performed by 3 orthopaedic surgeons (S.-M.L., W.C.S., and T.W.K.). An anteroposterior full–leg length radiograph, in which the patella was located at the midline, was taken 1 day before surgery to analyze the preoperative deformity. The target weightbearing line, which crossed the knee from the center of the hip joint to the center of the ankle, targeted 62.5% of the tibial plateau width at the medial border, and the correction angle and target were adjusted according to the intra-articular compartment status and cartilage status that were evaluated intraoperatively (during arthroscopy).[23,38] The instability and ligaments of the knee joint were evaluated during the physical examination and by analyzing magnetic resonance imaging scans before all surgeries; the diagnoses were confirmed during the arthroscopic examination, and partial meniscectomy was performed for all meniscal tears.[1,4,10,20,35]

For MOWHTO, a longitudinal incision of approximately 4 to 5 cm was made on the anterior ridge of the tibia, a part of the gracilis and semitendinosus tendons was released, and the superficial medial collateral ligament was detached below the osteotomy site. Two guide wires were inserted with the help of mobile fluoroscopic imaging, and an oblique incision was made 4 cm below the medial joint line toward the fibular head tip. After opening the osteotomy site using a laminar spreader, the proximal tibia was fixed using a locking plate (Tomofix [DePuy Synthes] or Ohtofix [Ohtomedical]), and the osteotomy site was bone grafted using the allogenic bone.[26]

Continuous passive motion exercise was initiated on the first day after surgery, partial weightbearing was initiated on the second week after surgery, and full weightbearing was allowed 4 to 6 weeks after surgery. Quadriceps strengthening and range of motion exercises were continued up to 3 months postoperatively.

## Statistical Analysis

Data were expressed as frequencies and percentages for categorical variables and as means ± SDs for continuous variables. Post hoc tests (multiple comparisons, Duncan, and Tukey honestly significant difference tests) were used to compare JSWs at different time points. A chi-square test or Fisher exact test was used to compare categorical data (for comparison of data for each group and cartilage grade of MFC and MTP), and a 3-way analysis of variance (ANOVA) model was used to analyze the factors affecting the change in the mean values of data obtained for each group, cartilage grade, and time point. A 3-way ANOVA was performed, omitting nonsignificant interactions and analyzing the effects of statistically significant associations. We analyzed the difference between the preoperative JSW and final JSW and whether there was a difference in the amount of change in JSW using the Kruskal-Wallis test.

Intraobserver and interobserver agreements were examined using the intraclass correlation coefficient (ICC) values, where an ICC of 1 indicated perfect agreement and ICC of 0 indicated nonagreement. ICC values were calculated for all measured data. All radiographic images were analyzed independently by 2 experienced orthopaedic surgeons (T.W.K. and S.-M.L.). Agreement was estimated using values measured at 2-week intervals. The range of interobserver agreement was 0.875 to 0.915, and the range of intraobserver agreement was 0.893 to 0.925. Overall, the values of intraobserver agreement were slightly higher than those of the interobserver agreement. The agreement was determined to be high (Table 1).

All analyses were performed using IBM SPSS statistical software Version 24.0 (IBM Corp). A $P$ value <.05 was considered statistically significant.

TABLE 1
Intraclass Correlation Coefficients Used for Assessment of Interobserver and Intraobserver Agreement[a]

| | Interobserver | Intraobserver |
|---|---|---|
| Preoperative JSW | 0.899 | 0.925 |
| 3-mo postoperative JSW | 0.909 | 0.893 |
| 6-mo postoperative JSW | 0.895 | 0.912 |
| 1-y postoperative JSW | 0.915 | 0.914 |
| 2-y postoperative JSW | 0.875 | 0.900 |

[a]JSW, joint space width.

## RESULTS

In this study, we assessed 179 patients diagnosed with and surgically treated for medial knee osteoarthritis at our institution between January 2016 and February 2020 (Figure 1). Of these, we excluded 42 patients whose follow-up was less than 2 years. In addition, of the remaining patients, we excluded one who underwent revision surgery and two who had insufficient radiographs. Therefore, 134 patients were included in the final group. The mean age of the patients was 55 ± 5.97 years (range, 32-64 years); 36 patients were men and 98 were women. The mean follow-up period was 43.4 ± 23 months (range, 25-117 months) (Table 2). After MOWHTO, the mean hip-knee-ankle angle changed from the preoperative varus at 9.20° ± 2.40° to the postoperative valgus at 1.67° ± 1.07°. The medial proximal tibial angle increased from 82.67° ± 2.04° before the surgery to 90.95° ± 2.51° after the surgery. Moreover, the joint line convergence angle decreased from 4.65° ± 1.54° to 2.43° ± 1.62°.

IKDC scores increased in all patients at 1 and 2 years postoperatively compared with the preoperative scores. The mean IKDC scores were 57.0 ± 4.9, 55.0 ± 6.2, and 53.4 ± 8.2 in the intact group, nonroot tear group, and root tear group, respectively, with no significant differences among the groups.

At 1 year postoperatively, the mean IKDC scores were 83.4 ± 4.3, 82.6 ± 4.8, and 81.3 ± 4.6, and at 2 years postoperatively, the mean IKDC scores were 84.2 ± 4.4, 82.4 ± 4.3, and 81.2 ± 4.2, respectively, with no differences among the groups. The scores of all groups increased after surgery (Table 3).

### Serial Changes in JSW at Different Time Points

The changes in JSW were examined in all patient groups, at 3, 6, and 12 months postoperatively and at the final follow-up (2 years). The preoperative JSW was 4.34 ± 1.34 mm, which increased to 4.87 ± 1.20 mm at 3 months postoperatively ($P < .001$). No significant change was observed in JSW from the final follow-up (4.86 ± 1.20 mm) to 12 months postoperatively (4.90 ± 1.22 mm) ($P < .104$). Table 4 shows the change in values of JSW in all patients at different time points.

Depending on the meniscal tear pattern, the patients were classified into 3 groups: the intact group without a tear, the nonroot tear group, and the root tear group. Patients who had multiple meniscal tears were included in the root tear group whenever a meniscus root tear was identified. Of the 134 patients, 29 had an intact meniscus, 47 had a root tear, and 58 had a nonroot tear. The greatest change in JSW after surgery was observed 6 months postoperatively in the intact group ($P < .005$), and the most significant change in JSW was found 3 months postoperatively in the root tear and nonroot tear groups ($P < .005$). The difference between the preoperative and final JSW was 0.29 ± 0.04 mm in the intact group, 0.34 ± 0.04 mm in the nonroot tear group, and 0.86 ± 0.09 mm in the root tear group, with the greatest increase in the root tear group ($P < .005$) (Figures 2 and 3).

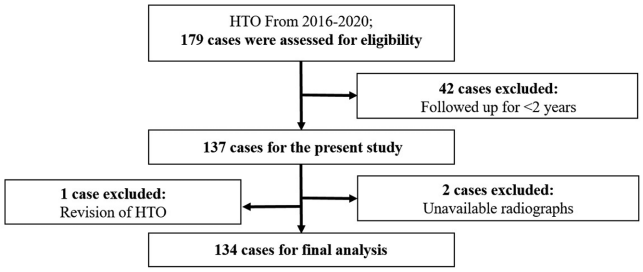


**Figure 1.** Flowchart of patient selection for this study. HTO, high tibial osteotomy.

TABLE 2
Patient Characteristics[a]

| | Value |
|---|---|
| All cases | 134 |
| Age, y | 55 ± 5.97 [32-64] |
| Sex | |
| Male | 36 (26.87) |
| Female | 98 (73.13) |
| Follow-up, mo | 43.4 ± 23.00 [25-117] |
| Side | |
| Right | 58 (43.28) |
| Left | 76 (56.72) |
| Height, m | 1.59 ± 0.08 [1.43-1.80] |
| Weight, kg | 66.02 ± 10.67 [44.7-92.4] |
| BMI | 26.00 ± 3.13 [20.10-34.03] |

[a]Data are presented as mean ± SD [range] or n (%). BMI, body mass index.

### Preoperative Cartilage Status and Adjusted JSW Analysis

In the root tear group, 31 patients (65.96%) had grade 4 MFC status, and this percentage was the highest among the 3 groups ($P = .006$). The MTP status of the root tear group was grade 4 in 32 patients (68.09%), and this percentage was higher than that of the other 2 groups ($P < .001$). The cartilage status of each group varied. Details are summarized in Table 5.

TABLE 3
International Knee Documentation Committee Scores of the Patients[a]

| | Intact Group | Nonroot Tear Group | Root Tear Group | *P* |
|---|---|---|---|---|
| Preoperative | 57.0 ± 4.9 | 55.0 ± 6.2 | 53.4 ± 8.2 | .181 |
| 1 y postoperative | 83.4 ± 4.3 | 82.6 ± 4.8 | 81.3 ± 4.6 | .325 |
| 2 y postoperative | 84.2 ± 4.4 | 82.4 ± 4.3 | 81.2 ± 4.2 | .210 |

[a]Data are presented as mean ± SD. *P* values were derived from the results of analysis of variance.

TABLE 4
Changes in JSW Analyzed Using Radiographic Outcomes[a]

| | JSW, mm | *P* |
|---|---|---|
| Preoperative finding | 4.34 ± 1.34 | |
| 3 mo postoperative | 4.87 ± 1.20 | <.001 |
| 6 mo postoperative | 4.88 ± 1.25 | .536 |
| 12 mo postoperative | 4.90 ± 1.22 | .116 |
| Final finding (2 y) | 4.86 ± 1.20 | .104 |

[a]Data are presented as mean ± SD. Each *P* value is compared with the *P* value of the previous period. JSW, joint space width.

Cartilage grades and changes in JSW depending on the tear pattern of the 3 groups were compared preoperatively, at 3 months and 6 months postoperatively, and at the final follow-up. No difference in the changes in JSW was observed in the 3 groups when adjusted for MTP status, but a difference in JSW changes was observed in the 3 groups when adjusted for MFC status. In other words, MTP status did not affect JSW, but MFC status affected JSW ($P = .003$) (Table 6).

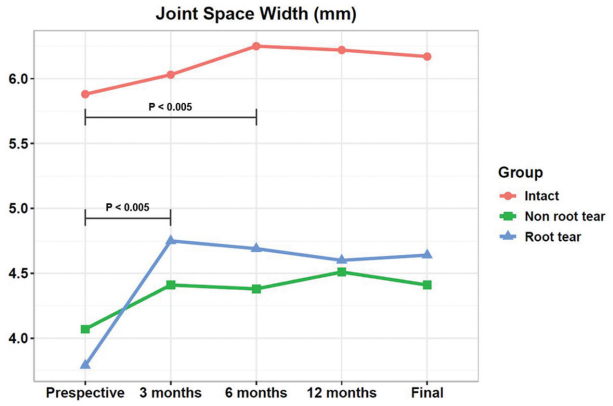


**Figure 2.** Change in joint space width (JSW) according to meniscal tear pattern. JSWs were measured using weightbearing radiographs after an opening-wedge high tibial osteotomy. The JSW significantly increased 6 months postoperatively in the intact group (right vertical axis). However, in the tear groups (root tear and nonroot tear), JSW increased 3 months postoperatively. There was a difference in the time point of change in JSWs between the groups ($P < .005$).

## DISCUSSION

In this study, we investigated the changes in JSW after MOWHTO by dividing the patients by meniscal tear pattern into intact, nonroot tear, and root tear groups and analyzed the effect of the preoperative cartilage status. There was an improvement in JSW in all groups; however, there was a difference in JSW according to the pattern of the medial meniscus. The improvement in JSW occurred sooner in the nonroot tear and root tear groups than in the intact group, and the change was the largest in the root tear group. The preoperative MFC status was determined to affect JSW. The IKDC score increased in all groups compared with preoperatively; however, there was no difference between groups.

For the meniscus, the circumferential hoop tension during weightbearing is a crucial factor, and strong bone attachment in the anterior and posterior directions and collagen arrangement should be maintained to sustain this tension.[11,14] According to Shrive et al,[36] radial and root tears that have progressed to the marginal area reach a state similar to that observed after complete resection of the medial meniscus in terms of changes in weightbearing caused by structural damage. Accordingly, a medial meniscus with a root tear represents a state similar to that observed after a subtotal or total meniscectomy of the medial meniscus, considering that JSW decreases the most after a medial meniscal subtotal or total meniscectomy.[3] Additionally, in our research, even though JSW in patients with root tears or nonroot tears improved after MOWHTO, it was still less than that of knees with an intact meniscus. It is believed that an HTO conducted at the right time may result in a significant increase in JSW.[23,26] However, further studies are required to confirm this hypothesis.

The cartilage grade of the femur altered the JSW after HTO, but the cartilage grade of the tibia did not. In the process of HTO surgery, to correct the alignment of the weightbearing axis and move it to the outer compartment to reduce the excessive load applied to the inner compartment,[1] osteotomy of the tibia is conducted, and subsequently, changes in alignment bring about the desired effect. Overall, the tibia is repositioned during the HTO surgery, whereas the femur remains relatively unchanged.[1,5,26,27,28,34] We believe that these findings explain why the grade of MFC cartilage observed before surgery affected the changes in JSW, whereas the grade of MTP cartilage did not, but further studies are required to confirm this hypothesis.

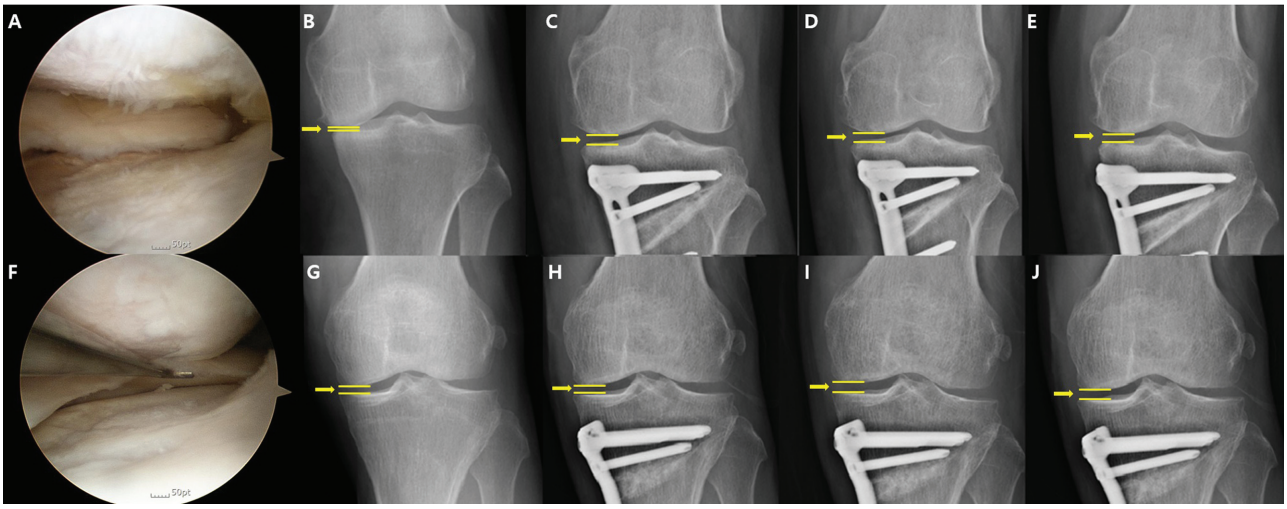


**Figure 3.** (A) Image obtained in a 54-year-old female patient with root tear. (B) The medial joint space width (JSW; yellow lines and arrows) is 1.25 mm. (C) The medial JSW is 4.76 mm at 3 months after surgery. (D) Plain radiograph showing that the medial JSW reduced to 4.64 mm at 6 months after surgery. (E) Radiographs obtained 1 year postoperatively showing no change in the medial JSW. (F) Image obtained in a 56-year-old male patient in the intact group. (G) The medial JSW is 2.27 mm. (H) The medial JSW is 5.12 mm at 3 months postoperatively. (I) Plain radiograph showing that the medial JSW at 6 months after surgery increased to 5.44 mm. (J) Radiographs obtained at 1 year postoperatively showing that the medial JSW reduced to 5.31 mm.

TABLE 5
Cartilage Status Assessed Using Outerbridge Grading System[a]

| Cartilage Grade | Intact Group, n = 29 | Nonroot Tear Group, n = 58 | Root Tear Group n = 47 | *P* |
|---|---|---|---|---|
| MFC | | | | .006 |
| 1 | 2 (6.90) | 1 (1.72) | 0 (0.00) | |
| 2 | 7 (24.14) | 8 (13.79) | 3 (6.38) | |
| 3 | 13 (44.83) | 16 (27.59) | 13 (27.66) | |
| 4 | 7 (24.14) | 33 (56.90) | 31 (65.96) | |
| MTP | | | | <.001 |
| 1 | 4 (13.79) | 1 (1.72) | 0 (0.00) | |
| 2 | 10 (34.48) | 7 (12.07) | 5 (10.64) | |
| 3 | 7 (24.14) | 23 (39.66) | 10 (21.28) | |
| 4 | 8 (27.59) | 27 (46.55) | 32 (68.09) | |

[a]Data are presented as n (%). MFC, medial femoral condyle; MTP, medial tibial plateau.

TABLE 6
Differences Between Joint Space Widths of Tear Groups With Adjusted Cartilage Grades at Different Time Points[a]

| | Intact Group | Nonroot Tear Group | Root Tear Group | *P* |
|---|---|---|---|---|
| MFC status adjusted | | | | |
| Preoperative | 5.87 ± 1.24 | 4.07 ± 1.01 | 3.79 ± 1.12 | .003 |
| 3 mo postoperative | 6.03 ± 1.21 | 4.41 ± 1.01 | 4.75 ± 1.01 | .008 |
| 6 mo postoperative | 6.25 ± 1.20 | 4.38 ± 0.99 | 4.70 ± 1.03 | .026 |
| Final follow-up | 6.17 ± 1.12 | 4.41 ± 0.97 | 4.64 ± 0.99 | .022 |
| MTP status adjusted | | | | |
| Preoperative | 5.88 ± 1.24 | 4.07 ± 1.01 | 3.79 ± 1.12 | .238 |
| 3 mo postoperative | 6.03 ± 1.21 | 4.41 ± 1.01 | 4.75 ± 1.01 | .293 |
| 6 mo postoperative | 6.25 ± 1.20 | 4.38 ± 0.99 | 4.69 ± 1.03 | .241 |
| Final follow-up | 6.17 ± 1.11 | 4.41 ± 0.97 | 4.64 ± 0.99 | .301 |

[a]Values are presented as mean ± SD. The relationship with 3 factors (tear group, MFC status, and MTP status) at each time point when joint space width was analyzed. Difference is in millimeters. MFC, medial femoral condyle; MTP, medial tibial plateau.

JSW is an indirect indicator of joint cartilage status and has been used as a reproducible tool for assessing progressive degeneration in the knee joint cartilage.[22,25,26,31,39] In the present study, an increase in JSW after MOWHTO in the root tear group was almost 1 mm, whereas in the other 2 groups JSW changes were <0.5 mm. These values appear to be larger than those of existing reports.[26,31,39] Our finding may be an effective indirect indicator of the cartilage protection ability of MOWHTO in the medial meniscus root tear group compared with other groups, but longer follow-up and detailed analysis are needed to confirm this result.

Differences in clinical outcomes based on the IKDC scores of the intact, nonroot tear, and root tear groups were not observed during the short-term follow-up. However, IKDC scores increased in all groups postoperatively, indicating improved clinical outcomes. It is imperative to highlight that these observations represent short-term outcomes, and the sustained maintenance of IKDC scores relative to JSW necessitates longer-term follow-up assessments. The intricate interplay between meniscal tear patterns, cartilage grades, and clinical scores warrants comprehensive exploration in future studies for a nuanced understanding of the outcomes after MOWHTO.

This study had a few limitations. First, there is a potential limitation of attrition bias because the total number of patients included in this study was relatively small and this was a retrospective study. However, we prospectively collected and analyzed the data for patients who underwent MOWHTO from 2016 to 2020. Second, selection bias could have occurred because in our study 23.5% of patients were lost to follow-up, and their data were subsequently excluded from the analysis. Last, the data were obtained from a single center. However, the outcomes of surgeries performed by multiple surgeons were analyzed, and the data were consistent.

## CONCLUSION

We observed that the amount and timing of increase in JSW were dependent on the pattern of a medial meniscal tear observed when MOWHTO was performed. After MOWHTO, the greatest increase in medial JSW was observed 6 months postoperatively in the intact group and 3 months postoperatively in the root tear and nonroot tear groups. The increase in JSW was greatest in the root tear group. In addition, the cartilage grade of MFC before surgery was associated with changes in JSW. The IKDC score increased from the preoperative to postoperative time point in all groups, but there was no significant difference. However, a longer follow-up period is needed to analyze the correlation with the meniscal tear pattern and JSW.

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