



# Midterm-clinical Outcomes after Hip Arthroscopy in Middle-aged Patients with Early Osteoarthritis

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**Purpose:** Although the number of hip arthroscopies is rapidly increasing in non-elderly patients, outcomes of this procedure in middle-aged patients are not well documented or clearly understood. The purpose of this study was to evaluate the clinical and radiological outcomes after hip arthroscopy in middle-aged patients with early osteoarthritis.

**Materials and Methods:** This retrospective study analyzed 189 patients with early osteoarthritis of various diagnoses aged 40 years or older who underwent hip arthroscopy between January 2010 and December 2015. Clinical (e.g., modified Harris hip score [mHHS], hip outcome score-activities of daily living [HOS-ADL], visual analogue scale [VAS] for pain, range of motion) and radiological (change of Tönnis grade) outcomes were assessed at a minimum of 3-year follow-up.

**Results:** The mean preoperative and final mHHS and HOS-ADL improved from 61.2 and 60.6 to 79.5 and 81.8, respectively, while the VAS pain score decreased from 6.3 to 3.2 ( $P<0.001$ ). Although the mean range of internal rotation and flexion increased from 14.2 and 100.7° preoperatively to 30.4 and 110.6° at 1-year postoperatively, they decreased slightly to 27.4 and 105.4° at the final follow-up, respectively. Eight cases (4.2%) underwent revision arthroscopic surgery and three cases (1.6%) were converted to total hip arthroplasty.

**Conclusion:** Patients with early-stage osteoarthritis of various diagnoses achieved improved clinical outcomes. Therefore, using hip arthroscopy in middle-aged patients with early osteoarthritis, it is possible to achieve good surgical options.

**Key Words:** Osteoarthritis, Hip arthroscopic surgery, Middle aged, Tönnis grade

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## INTRODUCTION

In the context of increased life expectancy, the number of patients in older age groups aiming to live an active life has been on the rise, despite their higher risk of developing osteoarthritis and hip osteoarthritis specifically<sup>1)</sup>. Recently, due to quicker postoperative recovery, and pain reduction compared to open surgical procedures<sup>2)</sup>, hip arthroscopy is gaining popularity as a hip-preserving surgical approach for those presenting with hip joint lesions<sup>3-5)</sup>.

Hip arthroscopy in young patients has been proven as an effective treatment option<sup>6-8)</sup>, while its effects in relatively

older patients are controversial<sup>9-11</sup>. Sing et al.<sup>2)</sup> reported that of all patients, those aged between 40 and 49 years undergoing hip arthroscopy accounted for the highest proportion (over 28% of cases) and those older than 60 years constituted more than 5%. Recent reports have shown promising outcomes with appropriate selection of middle-to-older-aged patients<sup>12-14</sup>.

However, clinical outcomes after hip arthroscopy in middle-aged patients with early osteoarthritis rather than with specific diagnoses (e.g., femoroacetabular impingement [FAI], labral tears) are rarely reported<sup>15,16</sup>. Therefore, the authors analyzed patients undergoing hip arthroscopic surgery among symptomatic patients aged 40 years or older with hip osteoarthritis. This retrospective observational study was designed to assess clinical and radiological outcomes after hip arthroscopy in middle-aged patients with early hip osteoarthritis with varying etiologies.

**MATERIALS AND METHODS**

The design of this study and protocol were approved by the Institutional Review Board at the Chungnam National University Hospital, and the requirement for informed consent was waived (IRB No. CNUH 2019-03-114).

Between January 2010 and December 2015, 250 patients who were older than 40 years and diagnosed with hip osteoarthritis underwent hip arthroscopic treatments and were possible enrollees for this study. Arthroscopic surgical indications required that patients had symptoms which persisted or deteriorated after preservation treatment (i.e., decreasing activity, medication, physical therapy, weight loss) and progressed after the occurrence of an obvious symptom. Upon physical examination, the combined hip range of motion (ROM) and levels of pain were measured using provocation tests, and the maximum value of joint motion was measured using a goniometer. Of the 250 possible subjects, 61 patients were excluded for one of the following reasons: (1) psychiatric medical history, (2) secondary gain, (3) a medical history of receiving hip arthroscopy on the same side, (4) a Tönnis score of greater than grade II, (5) non adherence to outpatient visits for at least three years, or (6) did not respond to the survey. The authors assumed that patients with secondary gain who were injured at work or injured in an accident and postponed the return to work or daily living. The remaining 189 patients were included in this study (118 male and 71 female; mean of 70.3 months [range: 36 to 107 months] follow-up). The mean age of the patients at the time of the index surgery

was 48.0 years (range: 40-67 years). The mean body mass index was 23.7 kg/m<sup>2</sup> (range: 18.1 to 31.6 kg/m<sup>2</sup>). Patients with early osteoarthritis of various diagnoses underwent hip arthroscopy (Table 1).

Arthroscopic surgeries in our study were performed in the typical manner by a highly skilled arthroscopic surgeon according to diagnosis or arthroscopic findings. Osteoplasty was performed to patients with FAI, and labral repair was performed in case of labral tear (Fig. 1). Patients with diffuse idiopathic skeletal hyperostosis or ankylosing spondylitis underwent femoroplasty and/or acetabuloplasty, and labral repair was considered as first treatment of choice when it was possible. Only four patients underwent labral debridement instead of labral repair in this study. Early osteoarthritis of various diagnoses, which is not typical FAI, was also treated with femoroplasty if there was a subchondral sclerosis or there was a possibility of impingement when the hip was flexed during surgery. In cases of cartilage damage, chondroplasty was performed on the acetabulum and/or femoral head. Thorough debridement, mass excision, and lavage were performed for synovial disease. Surgical failure was defined as a case that underwent revision arthroscopy or that required conversion to total hip arthroplasty (THA).

Patient diagnoses were categorized with symptoms, signs,

**Table 1.** Categorization of Patients Who Received Arthroscopic Surgery by Diagnosis

Diagnosis	Values (189 hips)
<b>FAI syndrome</b>	
FAI with labral tear	77
Labral tear without FAI evidence	40
Early degenerative osteoarthritis (without secondary arthritic evidence)	18
<b>Secondary osteoarthritis</b>	
Diffuse idiopathic skeletal hyperostosis	11
Borderline dysplastic hip	5
Ankylosing spondylitis	3
Legg-Calve-Perthes disease sequale	2
<b>Synovial disease</b>	
Synovial chondromatosis	14
Septic arthritis	7
Pigmented villonodular synovitis	3
<b>Miscellaneous</b>	
Traumatic osteoarthritis	6
Calcific tendinitis on gluteus medius	1
Chondrocalcinosis	1
Postoperative adhesion	1

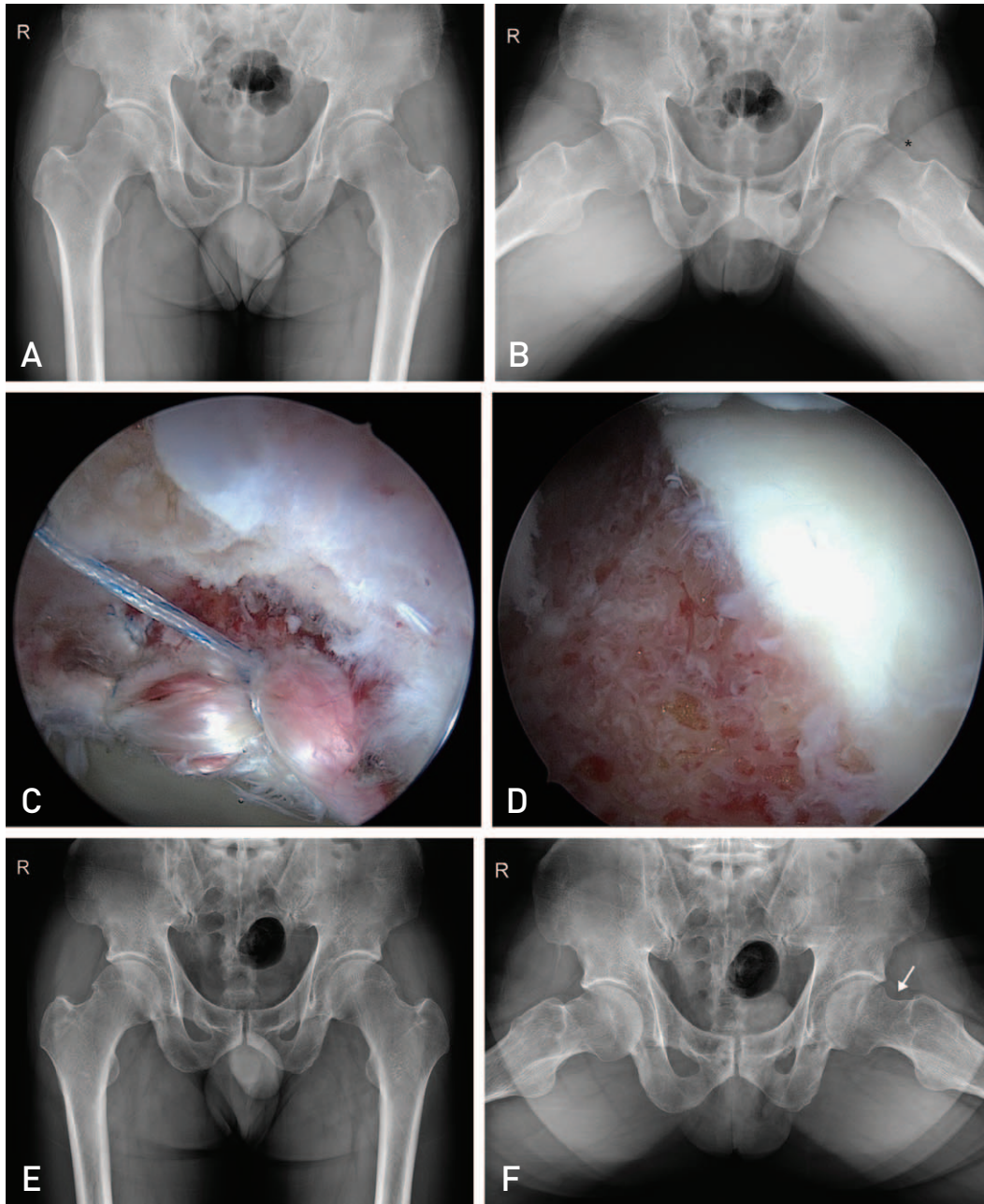
Values are presented as number only.  
FAI: femoroacetabular impingement

and imaging findings that meet the Warwick Agreement into the FAI syndrome patient group<sup>17</sup>. Those suffering from disorders of the synovium were classified into the synovial group, whereas those with other diagnoses formed the other group (Table 1). Early degenerative osteoarthritis diagnosis was performed if either typical FAI or other secondary osteoarthritis forms were excluded<sup>18</sup>. The severity of

osteoarthritis was categorized using the Tönnis classification.

### 1. Clinical Outcome Measure

Modified Harris hip score (mHHS), hip outcome score-activities of daily living (HOS-ADL), visual analogue scale (VAS) for pain, and VAS satisfaction were evaluated for all



**Fig. 1.** A 49-year-old male had a left hip femoroacetabular impingement with acetabular labral tear. He underwent arthroscopic labral repair using two anchors and arthroscopic osteoplasty. (A, B) Preoperative anteroposterior and frog-leg simple radiography. A Tönnis grade I osteoarthritis and decreased offset (asterisk) was observed. (C) Two anchors were used for labral repair. (D) Arthroscopic osteoplasty was performed to an existing femoral neck bump. (E, F) The last 50-month follow-up radiography. A Tönnis grade did not change (grade I), and sufficient osteoplasty was observed (arrow).

patients. With no single patient-reported outcome questionnaire available for patients undergoing hip arthroscopy, various outcome measurements were conducted at different points of time<sup>19</sup>). This survey was conducted prior to surgery, as well as six months, one year, and every year after surgery during outpatient visits. Scores were measured before surgery and at the midterm last follow-up for each patient, and collected data were then analyzed and presented in the form of statistics. The VAS satisfaction score reflects the outcome of the midterm last follow-up.

The patients' hip ROM was also measured, and only the internal rotation and flexion important to the anterior impingement test were used<sup>20</sup>). Internal rotation was measured while the hip was flexed at 90 degrees. Hip ROM was measured prior to surgery, as well as at six months, one year, and every year after surgery during outpatient visits. Angles before surgery, at one year of surgery, and at the midterm follow-up were measured for each patient and used for statistical analyses. To determine the effects of osteoplasty on ROM changes, patients diagnosed with FAI, diffuse idiopathic skeletal hyperostosis, or ankylosing spondylitis were categorized into Group 1 and the others as Group 2. Then, hip ROM of patients in Group 1 was compared with that of patients in Group 2.

## 2. Radiological Measure

Before surgery, simple radiography was used to obtain images in the pelvic anteroposterior view, false-profile view, frog-leg side view, and cross-table view. Three-dimensional computed tomography (CT) and magnetic resonance imaging (MRI) were performed to identify lesions and aid in differential diagnosis. Simple radiographs were taken preoperatively, as well as at six months, one year, and every year after surgery during outpatient visits. CT and MRI were also performed postoperatively if needed. Osteoarthritis of the hip joint was graded by the Tönnis classification through the findings of joint space narrowing, osteophytes, and bone contour or sclerosis in the pelvic anteroposterior view in the radiograph taken before and after surgery. Tönnis grade 0 are difficult to differentiate with or without arthritis. The authors therefore regarded patients with Tönnis grade 0 as having early osteoarthritis along with patients with Tönnis grade I. Tönnis grade II or more are classified as having advanced osteoarthritis<sup>21</sup>). Patients with Tönnis grade II or more were excluded. All radiographic films were independently interpreted by two specialists: a hip orthopedist participating in none of the

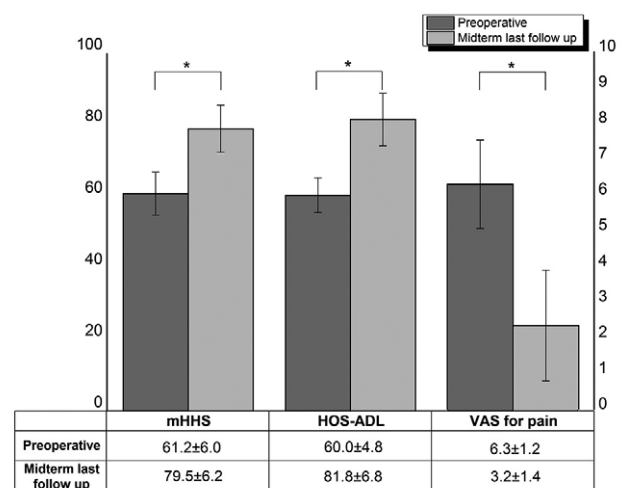
surgeries and a musculoskeletal radiologist. They had to make final judgements and reach a consensus about cases with different interpretations, if any. Diagnosis of borderline dysplasia was considered in cases with lateral center-edge angle values between 20 and 25 degrees.

## 3. Statistical Analysis

Statistical analyses were performed using IBM SPSS software ver. 24.0 (IBM Corp., Armonk, NY, USA). For the analyses of mHHS, HOS-ADL, and VAS for pain before surgery and at the final follow-up, paired *t*-tests were used. Independent *t*-test was used to compare the changes in Tönnis grades between groups. Changes in values by the time of hip joint ROM measurement and those by the time of measurement between groups were analyzed using repeated measures ANOVA. In all analyses, *P*<0.05 was defined as being significantly different.

## RESULTS

When comparing clinical outcomes at latest follow-up with preoperative assessments, all outcomes tested were significantly improved at each follow-up period (Fig. 2). At the latest follow-up, the mean preoperative and final mHHS and HOS-ADL improved from 61.2 and 60.6 to 79.5 and 81.8, respectively. The mean VAS pain score decreased



**Fig. 2.** Patient-reported outcomes (PROs) collected preoperative and at the midterm last follow-up. There was a significant difference in all PROs between preoperative and midterm last follow-up.

mHHS: modified Harris hip score, HOS-ADL: hip outcome score-activities of daily living, VAS: visual analogue scale.

\* Paired *t*-test, *P*<0.001.

from 6.3 to 3.2 ( $P<0.001$ ). Clinical outcomes in patients with Tönnis grade 0 and I were significantly improvements. Differences were observed in the levels of change only in HOS-ADL among those groups (Table 2). The mean VAS satisfaction score at the midterm last follow-up was 7.8 out of 10.

Although the mean range of internal rotation and flexion increased from prior to surgery to 1-year after surgery, these values were slightly lower at the final follow-up (Fig. 3A). Significant differences were observed in changes in internal rotation and flexion values over time ( $P<0.001$ ). Repeated measures ANOVA revealed significant differences in the mean changes in ROM between Groups 1 and 2 divided to determine the effects of osteoplasty on ROM changes (Fig. 3B, C).

At index surgery, 41 patients had Tönnis grade 0, 148 had Tönnis grade I (mean, 0.78). At the final follow-up, 18 patients had Tönnis grade 0, 127 had Tönnis grade I, 38 had Tönnis grade II, and 6 had Tönnis grade III (mean, 1.17).

Eight patients (4.2%) underwent revision arthroscopic surgery and three (1.6%) were converted to THA. Patients undergoing revision arthroscopy included three cases of labral tear without evidence of FAI, two cases of FAI with labral tear, one case of ankylosing spondylitis, borderline dysplastic hip, and synovial chondromatosis. Three patients who were converted to THA were diagnosed as experiencing early degenerative osteoarthritis, chondrocalcinosis (Fig. 4), and septic arthritis. Conversion to THA was performed in all of these three patients, since they had Tönnis grade III at the time of re-surgery and reported pain VAS scores of 7 to 8.

## DISCUSSION

Studies regarding clinical outcomes after hip arthroscopy in middle-aged patients with early osteoarthritis of various diagnoses are uncommon<sup>15,16</sup>. This study demonstrates that: (1) the mean preoperative and final mHHS and HOS-ADL were significantly improved at latest follow-up and (2) the mean VAS decreased significantly. The mean ROM of patients also increased, and the VAS satisfaction score was 7.8 out of 10. The results of this study suggest that middle-aged patients with early osteoarthritis have good clinical results after hip arthroscopy.

Although pain and clinical symptoms improve after hip arthroscopy, surgical outcomes in patients with more severe osteoarthritis became worse<sup>15,16</sup>. Horisberger et al.<sup>22</sup> identified that those with Tönnis grade III have poorer prognoses compared with those with Tönnis <III. Several other studies also suggested better prognosis in groups with lower Tönnis grades<sup>23-25</sup> and others identified an association between intraoperative cartilage degeneration and poor prognosis<sup>10,26</sup>. According to Philippon et al.<sup>27</sup>, patients aged 50 years or older with joint space width of less than 2 mm needed THA 9.9 times more than younger patients. A follow-up study pointed that in patients older than 50 years of age who underwent hip arthroscopy for FAI, about 80% with joint space width of less than 2 mm underwent THA<sup>28</sup>. Herrmann et al.<sup>10</sup> also noted that patients older than 40 years of age with a joint space width of <2 mm had a 75% likelihood of receiving THA.

Bedi et al.<sup>29</sup> found that appropriate osteoplasty in symptomatic patients with FAI can improve ROM and reduce secondary chondral injury through CT and 3-

**Table 2.** Patient-reported Outcomes of the Two Groups Divided by Tönnis Grade (0 and I)

Score	Preoperative	Midterm last follow-up	Change	<i>P</i> -value*	<i>P</i> -value <sup>†</sup>
mHHS					0.074
Tönnis grade 0	63.0±7.2	83.2±2.8	20.2±7.6	<0.001	
Tönnis grade I	60.7±5.8	78.4±6.7	17.7±8.0	<0.001	
HOS-ADL					0.003
Tönnis grade 0	63.4±5.8	87.6±4.1	24.2±6.9	<0.001	
Tönnis grade I	59.8±4.4	80.1±7.3	20.3±7.6	<0.001	
VAS for pain					0.141
Tönnis grade 0	6.0±1.3	2.6±0.9	3.4±1.4	<0.001	
Tönnis grade I	6.4±1.2	3.3±1.8	3.0±2.0	<0.001	

Values are presented as mean±standard deviation.

mHHS: modified Harris hip score, HOS-ADL: hip outcome score-activities of daily living, VAS: visual analogue scale.

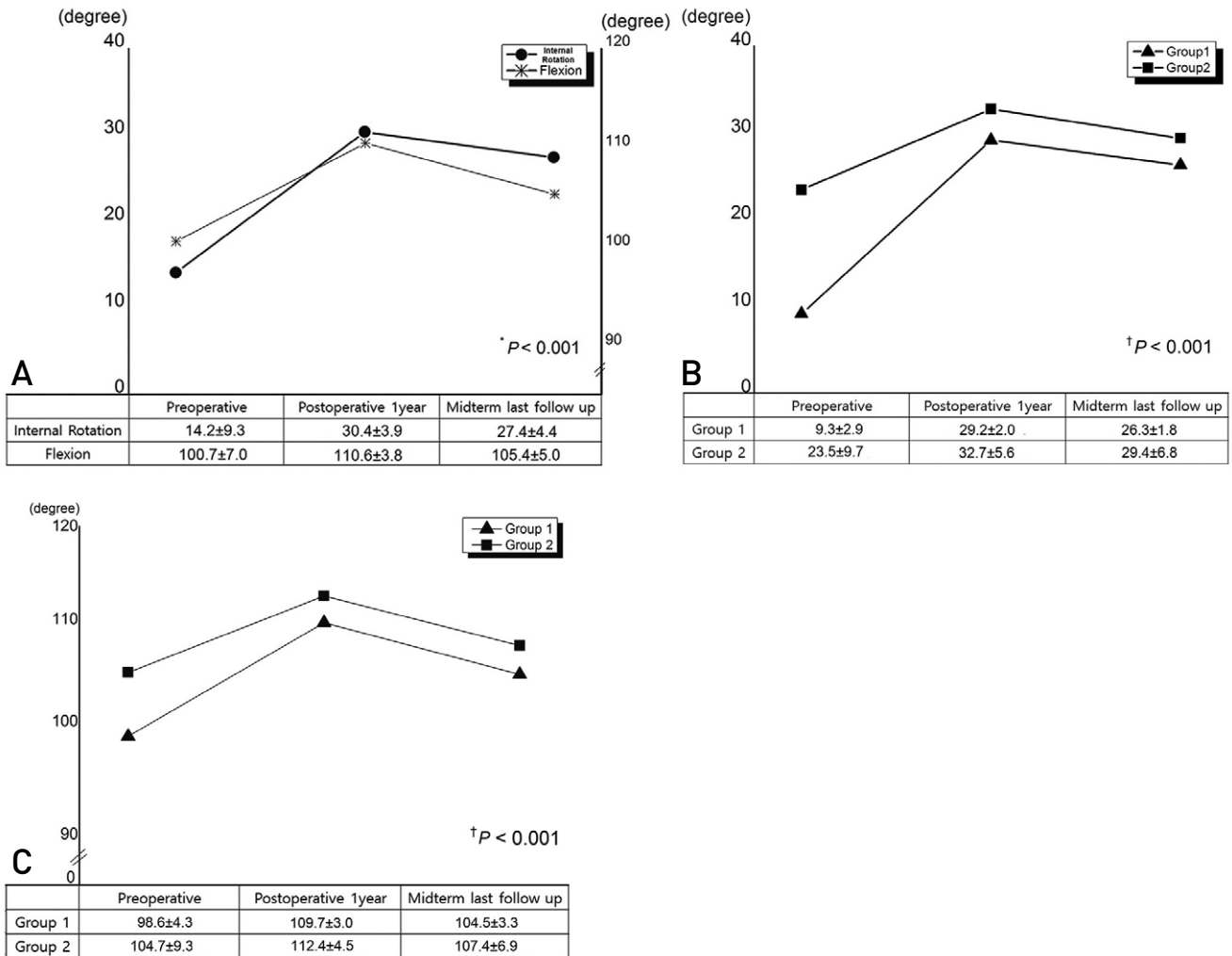
\* *P*-value: Paired *t*-test between before and after surgery.

† *P*-value: Independent *t*-test comparison of change values between before and after surgery by group.

dimensional modeling. In this study, internal rotation and flexion increased significantly after surgery, especially among patients receiving osteoplasty (Group 1) ( $P < 0.001$ ). The leading cause of revision arthroscopy is insufficient osteoplasty<sup>30,31</sup>. Ross et al.<sup>30</sup> found that 90% of symptomatic patients (45 of 50) with residual deformity received re-surgery. Philippon et al.<sup>31</sup> reported that re-surgeries were performed approximately 20.5 months after FAI and that the leading causes included hip pain, decreased ROM, and functional disability. After re-surgery, most patients were reported to partially recover from decreased functions

within 1 year. In this study, six out of eight cases of revision arthroscopy were thought to be caused by insufficient osteoplasty. After sufficient re-osteoplasty, all six patients had improved symptoms.

Kemp et al.<sup>16</sup> reported that patients with hip osteoarthritis received conversion to THA about 2 years after hip arthroscopy, while about 9.5% to 50% of patients in another review by Piuze et al.<sup>15</sup>, depending on the articles, underwent THA after a mean of 13.5 months. In our experience, during the 3- to 9-year midterm follow-up, three patients (1.6%) received conversion surgery to THA.

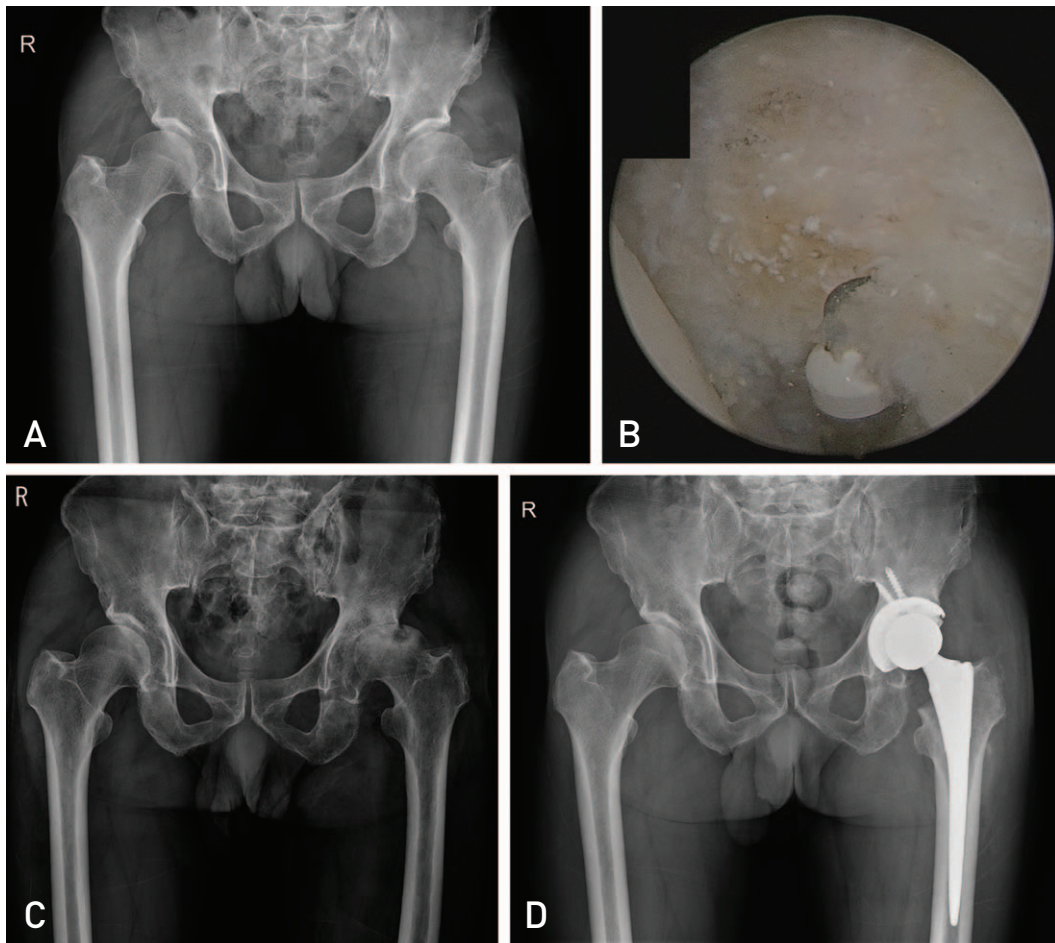


**Fig. 3.** The graphs reveal changes in range of motion over time. **(A)** Significant differences were observed between changes in the mean of internal rotation and flexion over time. **(B, C)** Repeated measures ANOVA revealed significant differences in the mean range of motion (ROM) (internal rotation, **B**; flexion, **C**) changes between the Group 1 and Group 2 divided to determine the effects of osteoplasty on ROM changes.

Group 1: patients diagnosed with femoroacetabular impingement, diffuse idiopathic skeletal hyperostosis, ankylosing spondylitis, Group 2: patients diagnosed with the others.

\* Huynh-Feldt epsilon,  $P < 0.001$

† Repeated measures ANOVA,  $P < 0.001$ .



**Fig. 4.** A 64-year-old male received arthroscopic partial removal of chondrocalcinosis and debridement on left hip. Primary diagnosis was chondrocalcinosis and borderline dysplastic hip. **(A)** This patient had a dysplastic hip on the right side and a borderline dysplastic hip on the left side (lateral center edge angle: 16° on right hip, 21° on left hip), and chondrocalcinosis on both sides. A Tönnis grade of 0 was observed in the preoperative period. **(B)** Arthroscopic debridement was performed on anterosuperior labrum. Calcific materials were observed. **(C)** A Tönnis grade III osteoarthritis was noted at the 12-month follow-up and his visual analogue scale for pain was 8. **(D)** He underwent conversion to total hip arthroplasty.

Here, it was thought that as surgery was only indicated in patients with early osteoarthritis or low Tönnis grade, lower THA conversion rates compared with other articles was achieved.

In this study, the mean Tönnis grade rose from 0.78 to 1.17, however, the clinical outcomes achieved were good. Kim et al.<sup>32)</sup> reported that hip pain was discordant with radiographic hip osteoarthritis. Repair of the labrum (which has sensory nerve endings), and osteoplasty (to prevent impingement) were thought to be the most important causes of pain relief<sup>33)</sup>. In addition, increased ROM due to sufficient osteoplasty may have contributed to the improvement of clinical results and patient satisfaction.

This study has some limitations. First, it is retrospective in nature and used midterm follow-up data. Secondly,

patients had a variety of diagnoses and with the exception of FAI and labral tear, most diagnoses included a relatively small number of patients, hence, size bias can occur in the interpretation of study results. Thirdly, selection bias can occur as all patients were treated in the outpatient setting. A possible explanation is that the skilled arthroscopy surgeon with his experience and knowledge selected patients to receive surgery who might inherently achieve good clinical outcomes. Finally, patients with diagnoses other than FAI rarely had early osteoarthritis with Tönnis grade 0. If the severity of osteoarthritis had been radiologically divided using Tönnis classification before surgery and there had been a control group, better outcomes might have been obtained.

## CONCLUSION

This study finds that patients with early-staged osteoarthritis of various diagnoses and with Tönnis grade 0 and I achieve improved clinical outcomes. Therefore, hip arthroscopic procedures in middle-aged patients can be a good surgical option if the surgeon selects appropriate patients and uses proper surgical procedure (e.g., sufficient osteoplasty).

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## CONFLICT OF INTEREST

The authors declare that there is no potential conflict of interest relevant to this article.

## REFERENCES

- Danielsson L, Lindberg H. *Prevalence of coxarthrosis in an urban population during four decades. Clin Orthop Relat Res.* 1997;(342):106-10.
- Sing DC, Feeley BT, Tay B, Vail TP, Zhang AL. *Age-related trends in hip arthroscopy: a large cross-sectional analysis. Arthroscopy.* 2015;31:2307-13.e2.
- Montgomery SR, Ngo SS, Hobson T, et al. *Trends and demographics in hip arthroscopy in the United States. Arthroscopy.* 2013;29:661-5.
- Schairer WW, Nwachukwu BU, McCormick F, Lyman S, Mayman D. *Use of hip arthroscopy and risk of conversion to total hip arthroplasty: a population-based analysis. Arthroscopy.* 2016;32:587-93.
- Lee JW, Hwang DS, Kang C, Hwang JM, Chung HJ. *Arthroscopic repair of acetabular labral tears associated with femoroacetabular impingement: 7-10 years of long-term follow-up results. Clin Orthop Surg.* 2019;11:28-35.
- Philippon MJ, Ejnisman L, Ellis HB, Briggs KK. *Outcomes 2 to 5 years following hip arthroscopy for femoroacetabular impingement in the patient aged 11 to 16 years. Arthroscopy.* 2012;28:1255-61.
- Jayakumar P, Ramachandran M, Youm T, Achan P. *Arthroscopy of the hip for paediatric and adolescent disorders: current concepts. J Bone Joint Surg Br.* 2012;94:290-6.
- Byrd JW, Jones KS. *Arthroscopic femoroplasty in the management of cam-type femoroacetabular impingement. Clin Orthop Relat Res.* 2009;467:739-46.
- Suarez-Ahedo C, Gui C, Rabe SM, Walsh JP, Chandrasekaran S, Domb BG. *Relationship between age at onset of symptoms and intraoperative findings in hip arthroscopic surgery. Orthop J Sports Med.* 2017;5:2325967117737480.
- Herrmann SJ, Bernauer M, Erdle B, Südkamp NP, Helwig P, Hauschild O. *Osteoarthritic changes rather than age predict outcome following arthroscopic treatment of femoroacetabular impingement in middle-aged patients. BMC Musculoskeletal Disord.* 2016;17:253.
- Wilkin G, March G, Beaulé PE. *Arthroscopic acetabular labral debridement in patients forty-five years of age or older has minimal benefit for pain and function. J Bone Joint Surg Am.* 2014;96:113-8.
- Javed A, O'Donnell JM. *Arthroscopic femoral osteochondroplasty for cam femoroacetabular impingement in patients over 60 years of age. J Bone Joint Surg Br.* 2011;93:326-31.
- Kim KC, Hwang DS, Lee CH, Kwon ST. *Influence of femoroacetabular impingement on results of hip arthroscopy in patients with early osteoarthritis. Clin Orthop Relat Res.* 2007;456:128-32.
- Griffin DW, Kinnard MJ, Formby PM, McCabe MP, Anderson TD. *Outcomes of hip arthroscopy in the older adult: a systematic review of the literature. Am J Sports Med.* 2017;45:1928-36.
- Piuzzi NS, Slullitel PA, Bertona A, et al. *Hip arthroscopy in osteoarthritis: a systematic review of the literature. Hip Int.* 2016;26:8-14.
- Kemp JL, MacDonald D, Collins NJ, Hatton AL, Crossley KM. *Hip arthroscopy in the setting of hip osteoarthritis: systematic review of outcomes and progression to hip arthroplasty. Clin Orthop Relat Res.* 2015;473:1055-73.
- Griffin DR, Dickenson EJ, O'Donnell J, et al. *The Warwick Agreement on femoroacetabular impingement syndrome (FAI syndrome): an international consensus statement. Br J Sports Med.* 2016;50:1169-76.
- Hoaglund FT, Steinbach LS. *Primary osteoarthritis of the hip: etiology and epidemiology. J Am Acad Orthop Surg.* 2001;9:320-7.
- Lodhia P, Slobogean GP, Noonan VK, Gilbert MK. *Patient-reported outcome instruments for femoroacetabular impingement and hip labral pathology: a systematic review of the clinimetric evidence. Arthroscopy.* 2011;27:279-86.
- Byrd JW. *Evaluation of the hip: history and physical examination. N Am J Sports Phys Ther.* 2007;2:231-40.
- Stelzeneder D, Mamisch TC, Kress I, et al. *Patterns of joint damage seen on MRI in early hip osteoarthritis due to structural hip deformities. Osteoarthritis Cartilage.* 2012;20:661-9.
- Horisberger M, Brunner A, Herzog RF. *Arthroscopic treatment of femoral acetabular impingement in patients with preoperative generalized degenerative changes. Arthroscopy.* 2010;26:623-9.
- Capogna BM, Ryan MK, Begly JP, Chenard KE, Mahure SA, Youm T. *Clinical outcomes of hip arthroscopy in patients 60 or older: a minimum of 2-year follow-up. Arthroscopy.* 2016;32:2505-10.
- Domb BG, Chaharbakshi EO, Rybalko D, Close MR, Litrenta J, Perets I. *Outcomes of hip arthroscopic surgery in patients with Tönnis grade 1 osteoarthritis at a minimum 5-year follow-up: a matched-pair comparison with a Tönnis grade 0 control group. Am J Sports Med.* 2017;45:2294-302.
- Chandrasekaran S, Gui C, Darwish N, Lodhia P, Suarez-Ahedo C, Domb BG. *Outcomes of hip arthroscopic surgery in patients with Tönnis grade 1 osteoarthritis with a minimum*



- 2-year follow-up: evaluation using a matched-pair analysis with a control group with Tönnis grade 0. *Am J Sports Med.* 2016;44:1781-8.
26. Egerton T, Hinman RS, Takla A, Bennell KL, O'Donnell J. Intraoperative cartilage degeneration predicts outcome 12 months after hip arthroscopy. *Clin Orthop Relat Res.* 2013; 471:593-9.
  27. Philippon MJ, Schroder E Souza BG, Briggs KK. Hip arthroscopy for femoroacetabular impingement in patients aged 50 years or older. *Arthroscopy.* 2012;28:59-65.
  28. Philippon MJ, Briggs KK, Carlisle JC, Patterson DC. Joint space predicts THA after hip arthroscopy in patients 50 years and older. *Clin Orthop Relat Res.* 2013;471:2492-6.
  29. Bedi A, Dolan M, Hetsroni I, et al. Surgical treatment of femoroacetabular impingement improves hip kinematics: a computer-assisted model. *Am J Sports Med.* 2011;39 Suppl:43S-9S.
  30. Ross JR, Larson CM, Adeoye O, Kelly BT, Bedi A. Residual deformity is the most common reason for revision hip arthroscopy: a three-dimensional CT study. *Clin Orthop Relat Res.* 2015;473:1388-95.
  31. Philippon MJ, Schenker ML, Briggs KK, Koppersmith DA, Maxwell RB, Stubbs AJ. Revision hip arthroscopy. *Am J Sports Med.* 2007;35:1918-21.
  32. Kim C, Nevitt MC, Niu J, et al. Association of hip pain with radiographic evidence of hip osteoarthritis: diagnostic test study. *BMJ.* 2015;351:h5983.
  33. Grant AD, Sala DA, Davidovitch RI. The labrum: structure, function, and injury with femoro-acetabular impingement. *J Child Orthop.* 2012;6:357-72.