Original Article

Simultaneous ipsilateral knee arthroscopy and unicondylar knee arthroplasty is effective for bicompartamental symptoms

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ABSTRACT

Background: Patients with unicompartmental radiographic arthritis but bicompartamental symptoms pose a clinical challenge. Some surgeons may perceive it as a contraindication for unicondylar knee arthroplasty (UKA). We investigated patient outcomes 2 years after simultaneous ipsilateral arthroscopy and UKA as compared to a similar group of patients who had total knee replacement (TKA) for a similar clinical presentation.

Methods: We identified 9 patients with simultaneous ipsilateral arthroscopy and UKA between 2004 and 2013, and 12 clinically similar patients treated with TKA.

Results: At 1- and 2-years, SF-12 physical scores were significantly improved in the UKA-scope group than in the TKA group (47.2 vs 40.3, $p=0.042$; 48.3 vs 32.6, $p=0.026$). WOMAC pain score, WOMAC stiffness score, WOMAC function and KSFS were significantly improved in the UKA-scope group at 2 years as compared to the TKA group (98.7 vs 63.8, $p=0.030$), (90.1 vs 43.8, $p=0.013$), (92.3 vs 55.2, $p=0.027$ and (92.3 vs 55.2, $p=0.027$), respectively). Change in score from baseline for KSFS, SF-12 physical and WOMAC stiffness were significantly improved in the UKA-scope group at 2 years compared to TKA, (28.3 vs -5, $p=0.041$), (13.6 vs 3.0, $p=0.026$), (52.6 vs -6.3, $p=0.025$), respectively.

Conclusion: This study shows that patients with isolated compartment radiographic disease but with bicompartamental symptoms can benefit from UKA and simultaneous arthroscopy. Further, TKA for isolated compartment radiographic disease in this limited series had poorer outcomes. We obtain MRI selectively when physical exam and radiographic findings suggest isolated arthritic disease in patients with bicompartamental symptoms.

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1. Introduction

Unicondylar knee arthroplasty (UKA) is an established treatment option for symptomatic osteoarthritis isolated to one compartment. Advocates of UKA suggest preservation of bone stock, knee kinematics and accelerated postoperative recovery as reasons for its use.^{1,2} Radiographic evidence of osteoarthritis such as joint space narrowing, osteophyte formation and malalignment of lower limb helps determine an indication for joint arthroplasty. There is little hesitation for diagnosis and treatment recommendations when symptoms, physical exam, and radiographs support isolated disease. Likewise, patients are not indicated for UKA when

symptoms and signs suggest poly-compartment degeneration because of concerns of failure and conversion to total knee. A conflict arises when the other compartment pathology is not due to degenerative arthritis but instead due to synovitis, cartilage flaps, or mechanical meniscus tears that are responsive to arthroscopic procedures. Though total knee arthroplasty (TKA) is an excellent treatment option for degenerative knee arthritis, a more limited surgery, if effective, may be preferable. Additionally, and increasingly important to our healthcare system, UKA is less costly than TKA.^{3–5}

Arthroscopic debridement, lavage, partial meniscectomy, and chondroplasty for osteoarthritic knees have had unpredictable outcomes.^{6–10} Simultaneous arthroscopic anterior cruciate ligament (ACL) reconstruction and UKA has been successful.^{11–14} TKA shortly following arthroscopy has been associated with poorer outcomes and higher complications.¹⁵ There is little literature related to arthroscopic treatment of meniscal tears at the time of UKA.¹⁶ We hypothesize that the simultaneous UKA and

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arthroscopic treatment of symptomatic meniscus tears and synovitis is an effective treatment, and better than TKA for patients with isolated compartment radiographic disease and bicompartamental symptoms.

2. Material and methods

A retrospective review of our joint registry was carried out after obtaining Institutional Review Board approval. Inclusion criteria consisted of treatment with simultaneous ipsilateral arthroscopy and UKA. Ten patients treated with 11 such simultaneous procedures were identified between May 2004 and November 2013. Two patients were excluded due to lack of follow-up, yielding 8 patients and 9 simultaneous UKA-scope procedures for our case cohort. Our comparison group comprised 12 patients over the same time frame treated with TKA who presented with bicompartamental symptoms but only unicompartamental radiographic disease. One patient in UKA –scope group had the same procedure on both knees staged by one year. All were performed by two fellowship-trained arthroplasty surgeons at a single institution.

Patient demographic data including age, gender, body mass index (BMI), American Society of Anesthesiologist score (ASA), ambulatory status, and range of motion were collected for both groups. In addition, MRI findings were collected for the UKA-scope group. We examined the surgical intervention, operative time, length of stay, physical therapy outcomes, disposition, range of motion, average visual analogue (VAS) pain scores and complications, conversions, or revision surgery for each group. Patient reported outcomes on the KSFS, WOMAC, and SF-12 were analyzed preoperatively and postoperatively at 3 months and yearly thereafter.^{17–19} The minimum follow-up was 2 years for both groups.

There were 8 patients and 9 knees in UKA-scope group and 12 patients in TKA group, with each group consisting of 66.7% and 75% females respectively. The mean age was 59.3 (range, 40–84) years in the UKA-scope group and 67 (range, 50–85) years in the TKA group, ($p=0.10$). Mean body mass index (BMI) was 31.6 kg/m² and 33 kg/m² respectively for UKA and TKA groups, respectively ($p=0.97$). Patient demographic characteristics for both groups are shown in Table 1.

In the UKA-scope group five operations were performed on the right and four on the left side. Seven were medial compartment

and two were lateral compartment arthroplasties. In one medial arthroplasty, the patellofemoral joint was also replaced. The latter case was not excluded because it fit the thesis that the opposite tibio-femoral compartment pathology but amenable to arthroscopy rather than arthroplasty, and a total knee arthroplasty was avoided. All nine knees were diagnosed with osteoarthritis of one compartment and meniscus pathology in the other compartment. Two knees had previous arthroscopic intervention for meniscus tears. All eight patients had preoperative MRI films revealing meniscus tearing in the non-replacement tibio-femoral compartment (Table 2). Intraoperative arthroscopic findings showed grade 1 to 2 chondromalacia of lateral compartment in six patients, grade 3 chondromalacia of the patellofemoral (PF) in one knee and grade 4 chondromalacia of the PF joint in one knee in which the PF joint was replaced. Seven knees underwent arthroscopic lateral meniscectomy and two underwent medial meniscectomy. Preoperative outcome measure scores, 2 years scores and change in scores for KSFS (Table 3), SF-12 P (Table 4) and WOMAC (pain and stiffness) (Table 5) are shown in tables. There were no statistically significant differences between the baseline scores of the two groups using Student *t*-test.

A midline incision with medial parapatellar approach was used for TKA and medial UKA. Lateral *para*-patellar arthrotomy was used for lateral UKA. In UKA-scope group, arthroscopy was performed first without the use of tourniquet. All implants were cemented and utilized a fixed bearing polyethylene liner. The patella was resurfaced in all TKA cases. Rehabilitation for all patients consisted of supervised physical therapy for strengthening and range of motion, weight bearing as tolerated, and assistive gait aid as required.

Routine follow-up visits and assessments occurred at 2 weeks, 3 months, and yearly thereafter. Patient reported outcomes were recorded at each visit. Preoperative scores, postoperative scores, and change in scores were analyzed. Change in score represents the effect of the intervention as per recent studies.^{20–23}

2.1. Statistical methods

Descriptive statistics included mean, standard deviation and ranges for continuous variables like age, BMI, ASA and all patients reported outcome measures. Discrete variables like gender, side of surgery and medial vs lateral compartment in UKA are expressed as frequencies and percentages. Comparisons between study

Table 1
Demographic Data for two groups.

Variable	Procedure		p value
	UKA-scope (n = 9)	TKA (n = 12)	
Gender (% Male)	66.7	75	0.015 ^a
Age (years) ^c	59.5 ± 15.7	67 ± 10	0.097
BMI	31.8 ± 6.8	33	0.69
Diagnosis			
OA	8	12	
Post infectious arthritis	1	0	
ASA ^c	2 ± 0.5	2.1 ± 0.5	0.714
Average 3 day pain score ^c	1.8 ± 1	2.2 ± 1.5	0.527
Follow-up time after surgery ^c	3.8 ± 2.9	2.4 ± 2.5	0.263
Operative time ^c	132 ± 16.8	109.2 ± 21.9	0.019 ^b
Operative side			
Right	5	2	0.061
Left	4	10	
Compartment involved on radiographs			
Medial	7	9	0.882
Lateral	2	3	

^a Chi-square test.

^b Student *t*-test.

^c Values are expressed as Mean ± Standard deviation (SD); UKA = unicompartamental knee arthroplasty, TKA = total knee arthroplasty.

Table 2
MRI findings and arthroscopic intervention in the UKA scope group.

Case No.	MRI findings in other compartment	Arthroscopic findings	Arthroscopic interventions
1	unavailable	Lateral meniscus tear	Meniscectomy, debridement
2	Lateral meniscus anterior horn tear	Lateral meniscus tear and grade II CM of PFJ	Meniscectomy
3	Lateral meniscus tear	Lateral meniscus tear and grade II CM of PFJ and lateral femoral condyle	Meniscectomy, chondroplasty
4	Lateral meniscus tear	Lateral meniscus tear and grade III CM PFJ	Meniscectomy, debridement
5	Lateral meniscus tear	Lateral meniscus tear and grade IV CM of PFJ	Debridement, biopsy
6	Lateral meniscus body tear	Lateral meniscus tear and grade II CM of PFJ	Meniscectomy
7	Lateral meniscus anterior horn tear	Lateral meniscus tear and grade I CM of PFJ	Meniscectomy
8	Medial meniscus tear	Medial meniscus tear and grade II CM of PFJ	Meniscectomy, debridement
9	Medial meniscus anterior horn tear	Medial meniscus anterior horn tear	Meniscectomy

CM = Chondromalacia, PFJ = patellofemoral joint.

Table 3
Preoperative, 2 year and change in score KSFS at 2 years.

KSFS	Procedure	Mean $\pm$ SD	p value
Preoperative			
	UKA-scope	56.7 $\pm$ 17.1	
	TKA	51.9 $\pm$ 19.4	0.704
2 Years			
	UKA-scope	83.3 $\pm$ 20.7	
	TKA	45 $\pm$ 13.2	0.023 ^a
Change			
	UKA-scope	28.3 $\pm$ 22.3	
	TKA	5 $\pm$ 0	0.04 ^a

^a Student *t*-test showing statistically significant improvement in scores.

Table 4
Preoperative, 2 years and change in score SF-12 at 2 years.

SF-12	Procedure	Mean $\pm$ SD	p value
Preoperative			
SF-12 P	UKA-scope	30.9 $\pm$ 5.2	
	TKA	29.9 $\pm$ 8.8	0.957
SF-12 M	UKA-scope	48.9 $\pm$ 7.7	
	TKA	47.4 $\pm$ 10.5	0.871
2 years			
SF-12 P	UKA-scope	48.3 $\pm$ 5.8	
	TKA	32.6 $\pm$ 11.0	0.026 ^a
SF-12 M	UKA-scope	59.7 $\pm$ 5.8	
	TKA	49.6 $\pm$ 11.1	0.076
Change			
SF-12 P	UKA-scope	13.6 $\pm$ 7.4	
	TKA	3.1 $\pm$ 6.6	0.026 ^a
SF-12 M	UKA-scope	13.6 $\pm$ 7.4	
	TKA	3.6 $\pm$ 8.2	0.051

^a Student *t*-test showing statistically significant improvement in scores.

groups were performed with Student's *t*-test for continuous variables and chi-square test for categorical variables. All tests were two-sided, and $p < 0.05$ was the threshold for statistical significance using SPSS (Version 23.0, IBM, Chicago, IL).

3. Results

There were no significant differences between groups for age, American society of anesthesiologists (ASA) score, follow-up after surgery, BMI, or diagnosis (Table 1). The mean follow-up was 3.8 years (SD = 2.9, range 0.25–4 years) for the UKA-scope group and 2.4 years (SD = 2.5, range 0.25–6 years) for TKA group ($p = 0.262$). There were no significant differences between the preoperative KSFS, WOMAC pain, WOMAC stiffness, WOMAC function, SF-12

mental, or SF-12 physical scores ($p > 0.128$) (Tables 3–5). There were no significant differences between the preoperative range of motion between the two groups ($p = 0.175$). Mean operative time was 131.6 min (SD = 17.9, range, 105–162) and 115.2 min (SD = 28.5, range 83–165) respectively for UKA-scope and TKA groups, $p = 0.019$. The mean length of stay in the hospital was 3.1 (SD = 0.6, range, 2.2–4.3) and 3.2 days (SD = 0.5, range, 2.2–4.4) for the UKA-scope and TKA groups respectively. In the UKA-scope group, 7 patients were discharged home, one was discharged to a rehabilitation center, and one was discharged to skilled nursing care facility (SNF). In the TKA group 6 patients went home and 6 patients were discharged to rehabilitation center.

KSFS score was significantly improved in the UKA-scope group at 2 years as compared to the TKA group (83.3 vs 45, $p = 0.023$). SF-12 physical score was significantly improved at 1 year and 2 years in the UKA-scope group compared to TKA group (47.2 vs 40.3, $p = 0.042$; 48.3 vs 32.6, $p = 0.026$). WOMAC pain, WOMAC stiffness, and WOMAC function scores were significantly improved in the UKA-scope group at 2- years as compared to TKA group ((98.7 vs 63.8, $p = 0.030$), (90.1 vs 43.8, $p = 0.013$), and (92.3 vs 55.2, $p = 0.027$) respectively). There was no significant difference between the two groups in SF-12 mental component, $p > 0.076$. Range of motion (ROM) at 3 months for the UKA-scope group was better than the TKA group, but it was not statistically significant (124.3 vs 113.8, $p = 0.058$). Likewise, there was no statistical difference in ROM at 1-year and 2-years ($p = 0.206$ and $p = 0.683$ respectively).

At 2 years follow-up, the UKA-scope group had a better improvement in KSFS (28.3 vs –5, $p = 0.040$), SF-12 physical score (13.6 vs 3.0, $p = 0.026$), and WOMAC stiffness score (52.6 vs –6.3, $p = 0.024$). Improvements in SF-12 mental and WOMAC function scores were not statistically significant at 2 years (13.6 vs 3.9, $p = 0.051$), (57.0 vs 18.4, $p = 0.062$) respectively. There was no significance difference in the change in score for WOMAC pain at 2 years (57.5 vs 28.8, $p = 0.108$). Neither group had any complications. There were no infections, revisions, or reoperations in either group.

4. Discussion

Both UKA and TKA lead to improvement in functional outcomes.^{25–29} TKA has been reported to be more durable than UKA.²⁴ Advocates of UKA cite better functional outcome over TKA.^{30–32} However, patients with isolated compartment radiographic disease but bicompartamental symptoms may not be offered UKA. We found that when these patients have mechanical symptoms related to meniscal tear, a simultaneous arthroscopy and UKA is effective and may be better than TKA. It is unclear why our 12 TKA patients in the comparison group had overall bad outcomes and poorer functional scores than prior to surgery. It is possibly related to the early-grade preoperative osteoarthritis in the opposite compartment and known associations with pain and dissatisfaction.³³ It is more probably an aberrancy of our low number in the group, and no conclusions should be made from

Table 5

Preoperative, 2 years and change in score WOMAC at 2 years.

WOMAC domain	Procedure	Mean $\pm$ SD	p value
Preoperative Pain	UKA-scope	52.9 $\pm$ 15.2	0.766
	TKA	49.3 $\pm$ 28.8	
Stiffness	UKA-scope	51.8 $\pm$ 15.2	0.607
	TKA	46.6 $\pm$ 23.1	
Function	UKA-scope	49.8 $\pm$ 19.5	0.787
	TKA	52.8 $\pm$ 22.9	
2 years Pain	UKA-scope	98.8 $\pm$ 25.3	0.03 ^a
	TKA	63.8 $\pm$ 24.6	
Stiffness	UKA-scope	90.1 $\pm$ 12.2	0.013 ^a
	TKA	43.8 $\pm$ 23.9	
Function	UKA-scope	92.3 $\pm$ 13.5	0.027 ^a
	TKA	55.2 $\pm$ 21.8	
Change Pain	UKA-scope	57.5 $\pm$ 25.3	0.108
	TKA	28.8 $\pm$ 17.0	
Stiffness	UKA-scope	52.6 $\pm$ 33.2	0.024 ^a
	TKA	neg 6.3 $\pm$ 21.7	
Function	UKA-scope	57.0 $\pm$ 29.1	0.062
	TKA	18.4 $\pm$ 17.4	

^a Student *t*-test showing statistically improvement in scores.

these results. Further study and larger cohorts are needed to understand whether bicompartamental symptoms and unicompartamental radiographic disease have poor outcomes after TKA.

There are several limitations to this study. First, this study focuses on a narrow constellation of symptoms, namely bicompartamental pain with unicompartamental radiographic disease. This limits the generalizability of our findings and also explains the small number of subjects in our groups. Further, data of the study spans a decade. This could be a confounding factor with respect to implants, technique, and operative indications but the same confounding variable applies to both groups. Additionally, capturing simultaneous arthroscopy and UKA patients is reliable within our database, but finding appropriate comparison subjects who had TKA was more challenging and required delving into the medical record to identify the specific constellation of symptoms. The TKA group was equally small, which could skew the functional outcome scores for that group. Nonetheless, this retrospective report shows that bicompartamental joint line tenderness need not necessarily exclude UKA as a treatment option. Finally, with our low numbers in each group, we are not powered to determine statistical conclusions of “no difference” between groups. Thus our results should be considered in light of this low *n* and only our positive statistical findings should contribute to our understanding of these patients.

Arthroscopy after UKA for meniscal pathology and retained cement has been reported with good results.^{34–37} Arthroscopy has been used at the time of extra-articular osteotomy to evaluate cartilage and to refine the reconstructive plan.³⁸ Liu et al.¹⁶ reported good outcomes on 24 patients indicated for UKA who had arthroscopy at the beginning of surgery. UKA was aborted in 8 patients due to advanced disease in other compartments, all underwent synovectomy, 5 underwent meniscal intervention, and 11 underwent other arthroscopic procedures. Our study is consistent with these varying reports about the use of arthroscopy as an adjunct procedure. Further, we show that arthroscopy can help expand surgical treatment options to include UKA rather than just TKA. We had no aborted UKAs following arthroscopy, and this was likely due to information obtained from the preop MRI in these patients. We are unable to determine from our database a

denominator of how many patients obtained an MRI that caused the surgeon to change from planned UKA-scope to TKA prior to the surgery date.

In conclusion, a viable option for patients who would be candidates for UKA if not for bicompartamental tenderness is to obtain MRI and consider arthroscopy at the time of UKA. In our experience, it is difficult to completely assess the other compartment from a UKA exposure. Therefore, MRI is a useful preoperative study and helps to guide treatment. Simultaneous arthroscopy and UKA is a reasonable treatment option to offer patients, as we found good results in 8 patients who underwent simultaneous UKA and arthroscopy.

References

- Newman JH, Ackroyd CE, Shah NA. Unicompartamental or total knee replacement? Five-year results of a prospective, randomized trial of 102 osteoarthritic knees with unicompartamental arthritis. *J Bone Joint Surg Br.* 1998;80(5):862–865.
- Laurencin CT, Zelicof SB, Scott RD, Ewald FC. Unicompartamental versus total knee arthroplasty in the same patient. A comparative study. *Clin Orthop Relat Res.* 1991;273:151–156.
- Slover J, Espehaug B, Havelin LI, et al. Cost-effectiveness of unicompartamental and total knee arthroplasty in elderly low-demand patients. A Markov decision analysis. *J Bone Joint Surg Am.* 2006;88(November (11)):2348–2355.
- Willis-Owen CA, Brust K, Alsop H, et al. Unicompartmental knee arthroplasty in the UK National Health Service: an analysis of candidacy, outcome and cost efficacy. *Knee.* 2009;16(December (6)):473–478.
- Soohoo NF, Sharifi H, Kominski G, Lieberman JR. Cost-effectiveness analysis of unicompartamental knee arthroplasty as an alternative to total knee arthroplasty for unicompartamental osteoarthritis. *J Bone Joint Surg Am.* 2006;88(September (9)):1975–1982.
- Katz JN, Brophy RH, Chaisson CE, et al. Surgery versus physical therapy for a meniscal tear and osteoarthritis. *N Engl J Med.* 2013;368(18):1675–1684.
- Jackson RW, Dieterichs C. The results of arthroscopic lavage and debridement of osteoarthritic knees based on the severity of degeneration: a 4- to 6-year symptomatic follow-up. *Arthroscopy.* 2003;19(1):13–20.
- Harwin SF. Arthroscopic debridement for osteoarthritis of the knee: predictors of patient satisfaction. *Arthroscopy.* 1999;15(2):142–146.
- Dhawan A, Mather III RCIII, Karas V, et al. An epidemiologic analysis of clinical practice guidelines for non-arthroplasty treatment of osteoarthritis of the knee. *Arthroscopy.* 2014;30(1):65–71.
- Thorlund JB, Juhl CB, Roos EM, Lohmander LS. Arthroscopic surgery for degenerative knee: systematic review and meta-analysis of benefits and harms. *BMJ.* 2015;350:h2747.
- Ventura A, Legnani C, Terzaghi C, Iori S, Borgo E. Medial unicompartmental knee arthroplasty combined to anterior cruciate ligament reconstruction. *Knee Surg Sports Traumatol Arthrosc.* 2017;10.1007/s00167-015-3808-0.
- Weston-Simons JS, Pandit H, Jenkins C, et al. Outcome of combined unicompartamental knee replacement and combined of sequential anterior cruciate ligament reconstruction. *J Bone Joint Surg Br.* 2012; 94-B: 1216–20.
- Tinius M, Hepp P, Becker R. Combined unicompartamental knee arthroplasty and anterior cruciate ligament reconstruction. *Knee Surg Sports Traumatol Arthrosc.* 2012;20:81–87.
- Krishnan RS, Randle R. ACL reconstruction with unicompartmental replacement in knee with functional instability and osteoarthritis. *J Orthop Surg Res.* 2009;4:43.
- Werner CB, Burrus TM, Novicoff MW, Browne AJ. Total knee arthroplasty within six months after knee arthroscopy is associated with increased postoperative complications. *J Arthroplasty.* 2015;30:1313–1316.
- YJ Liu, Li ZL, Wang ZG, et al. The value of arthroscopic techniques in determination of indications of unicompartmental arthroplasty. *Zhonghua Yi Xue Za Zhi.* 2007;87(March (9)):590–593 Article in Chinese.
- Scuderi GR, Bourne RB, Noble PC, Benjamin JB, Lonner JH, Scott WN. The new knee society knee scoring system. *Clin Orth Rel Res.* 2012;470(1):3–19.
- Bellamy N. WOMAC Osteoarthritis Index User Guide. Version V. Brisbane, Australia 2002.
- Ware JE, Kosinski M, Keller SD. A 12-item short-form health survey: construction of scales and preliminary tests of reliability and validity. *Med Care.* 1996;34(3):220–233.
- Kostamo T, Bourne RB, Whittaker JP, McCalden RW, MacDonald SJ. No difference in gender-specific hip replacement outcomes. *Clin Orthop Relat Res.* 2009;467:135–140.
- MacDonald SJ, Charron KD, Bourne RB, Naudie DD, McCalden RW, Rorabeck CH. The John Insall Award: gender-specific total knee replacement: prospectively collected clinical outcomes. *Clin Orthop Relat Res.* 2008;466:2612–2616.
- McCalden RW, Charron KD, MacDonald SJ, Bourne RB, Naudie DD. Does morbid obesity affect the outcome of total hip replacement? An analysis of 3290 THRs. *J Bone Joint Surg Br.* 2011;93:321–325.

23. Rajgopal V, Bourne RB, Chesworth BM, MacDonald SJ, McCalden RW, Rorabeck CH. The impact of morbid obesity on patient outcomes after total knee arthroplasty. *J Arthroplasty*. 2008;23:795–800.
24. McAllister CM. The role of unicompartmental knee arthroplasty versus total knee arthroplasty in providing maximal performance and satisfaction. *J Knee Surg*. 2008;21:286–292.
25. Ackroyd CE, Whitehouse SL, Newman JH, Joslin CC. A comparative study of the medial Sled and Kinematic total knee arthroplasties: ten-year survivorship. *J Bone Joint Surg Br*. 2002;84:667–672.
26. Aglietti P, Buzzi R, De Felice R, Giron F. The Insall-Burstein total knee replacement in osteoarthritis: a 10-year minimum follow-up. *J Arthroplasty*. 1999;14:560–565.
27. Naudie D, Guerin J, Parker DA, Bourne RB, Rorabeck CH. Medial unicompartmental knee arthroplasty with the Miller-Galante prosthesis. *J Bone Joint Surg Am*. 2004;86:1931–1935.
28. Rougraff BT, Heck DA, Gibson AE. A comparison of tricompartmental and unicompartmental arthroplasty for the treatment of gonarthrosis. *Clin Orthop Relat Res*. 1991;273:157–164.
29. Whittaker JP, Naudie DD, McAuley JP, McCalden RW, Mac-Donald SJ, Bourne RB. Does bearing design influence midterm survivorship of unicompartmental arthroplasty? *Clin Orthop Relat Res*. 2010;468:73–81.
30. Amin AK, Patton JT, Cook RE, Gaston M, Brenkel IJ. Unicompartmental or total knee arthroplasty? Results from a matched study. *Clin Orthop Relat Res*. 2006;451:101–106.
31. Griffin T, Rowden N, Morgan D, Atkinson R, Woodruff P, Maddern G. Unicompartmental knee arthroplasty for the treatment of unicompartmental osteoarthritis: a systematic study. *ANZ J Surg*. 2007;77:214–221.
32. Walton NP, Jahromi I, Lewis PL, Dobson PJ, Angel KR, Campbell DG. Patient-perceived outcomes and return to sport and work: TKA versus mini-incision unicompartmental knee arthroplasty. *J Knee Surg*. 2006;19:112–116.
33. Polkowski 2nd GC2nd, Ruh EL, Barrack TN, Nunley RM, Barrack RL. Is pain and dissatisfaction after TKA related to early-grade preoperative osteoarthritis? *Clin Orthop Relat Res*. 2013;471(January (1)):162–168.10.1007/s11999-012-2465-6.
34. Shah MM, Yunus SA. Bucket-handle tear in retained meniscus after unicompartmental knee arthroplasty. *Arthroscopy*. 2003;19(July–August (6)) E-11.
35. Jung KA, Lee SC, Song MB. Lateral meniscus and lateral femoral condyle cartilage injury by retained cement after medial unicompartmental knee arthroplasty. *J Arthroplasty*. 2008;23(October (7)):1086–1089.10.1016/j.arth.2007.09.025 Epub 2008 Jan 24.
36. Howe DJ, Taunton Jr. ODJr., Engh GA. Retained cement after unicompartmental knee arthroplasty. A report of four cases. *J Bone Joint Surg Am*. 2004;86-A(October (10)):2283–2286.
37. Elmadag M, Imren Y, Erdil M, Bilsel K, Tuncay I. Excess retained cement in the posteromedial compartment after unicompartmental knee arthroplasty. *Acta Orthop Traumatol Turc*. 2013;47(4):291–294.
38. Strecker W, Dickschas J, Harrer J, et al. Arthroscopy prior to osteotomy in cases of unicompartmental osteoarthritis. *Orthopäde*. 2009;38:26310.1007/s00132-008-1390-6 Article in German.