ACTA
ORTHOPAEDICA
et
TRAUMATOLOGICA
TURCICA

Acta Orthop Traumatol Turc 2010;44(2):135-142
doi:10.3944/AOTT.2010.2296

Short-term results of the Oxford phase 3 unicompartmental knee arthroplasty for medial arthritis

Atilla Sancar PARMAKSIZOĞLU, Yavuz KABUKÇUOĞLU, Ufuk ÖZKAYA, Fuat BİLGİLİ, Armağan ASLAN

Department of Orthopedics and Traumatology, Taksim Training and Research Hospital, İstanbul

Objectives: We evaluated short-term results of the Oxford phase 3 unicompartmental knee arthroplasty (UKA) in patients with medial compartment arthritis.

Methods: The study included 38 patients (28 females, 10 males; mean age 67 years; range 56 to 75 years) who underwent UKA for isolated medial knee osteoarthritis. At the time of surgery, 28 patients were in the age group of 56-64 years, and 10 patients were in the age group of 65-75 years. All the patients had Ahlbäck grade 2 primary medial compartment arthritis that had been unresponsive to conservative treatment. None of the patients had symptoms of patellofemoral arthrosis. Patients underwent UKA with the Oxford phase 3 cemented meniscal-bearing unicondylar prosthesis using minimally invasive surgery. The results were assessed preoperatively and at final controls according to the Knee Society clinical and functional rating system. Postoperative radiographic evaluations were made according to the Oxford criteria. The mean follow-up period was 24 months (range 18 to 32 months).

Results: The mean preoperative active knee flexion increased from 121.8° (range 110° to 130°) to 130.9° (range 120° to 140°) postoperatively ($p<0.05$). There was no limitation in knee extension both pre- and postoperatively. The mean preoperative and postoperative knee scores were 64.6 (range 47 to 80) and 97.5 (range 89 to 100), and the mean functional scores were 59.6 (range 45 to 80) and 92.1 (range 70 to 100), respectively ($p<0.05$). All the patients had an excellent knee score, while functional scores were excellent in 27 patients (71.1%) and good in 11 patients (28.9%). Postoperative radiographic measurements showed that the position of the femoral components was within acceptable ranges in all the patients with a mean of 3° valgus (range 5° valgus to 8° varus) and 0.5° extension (range 3° extension to 2° flexion). The positioning of the femoral components in relation to the mechanical axis was central in 30 patients and 2-mm lateral (range 2 mm medial to 4 mm lateral) in eight patients. The position of the tibial components was also within acceptable ranges in all the patients with a mean of 1.5° varus (range 2° varus to 2° valgus) and a mean posterior inclination of 6.2° (range 5° to 7°). All the tibial components showed full congruency with the medial, lateral, anterior, and posterior planes, except for one which had a 4-mm undersizing in the anterior plane. The polyethylene insert was central and parallel to the tibial component in all the patients. No osteophytes or cement debris that might lead to impingement were observed. All the components remained in position until the final controls. Complications such as insert dislocation, infection, pulmonary embolism, deep venous thrombosis, or neurovascular injury were not observed. None of the patients required revision surgery.

Conclusion: Our findings show that, with proper patient selection and strict adherence to the surgical technique, short-term results of the Oxford phase 3 unicompartmental knee prosthesis are excellent or good in the treatment of medial compartment osteoarthritis.

Key words: Arthroplasty, replacement, knee/methods; knee joint; knee prosthesis; osteoarthritis, knee/surgery; prosthesis design.

Correspondence: Ufuk Özkaya, MD. Taksim Eğitim ve Araştırma Hastanesi, Ortopedi ve Travmatoloji Kliniği, 34433 Beyoğlu, İstanbul, Turkey. Tel: +90 212 - 252 43 00 / 1409 e-mail: ufukozkaya2004@yahoo.com

Submitted: July 10, 2009 **Accepted:** November 23, 2009

Medial compartment osteoarthritis of the knee is common. Surgical treatment options include high tibial osteotomy, total knee arthroplasty, or unicompartmental knee arthroplasty (UKA), depending on the patient's age, level of physical activity, and the degree of deformity.[1-5] The advantages of UKA include preservation of bone stock, smaller incision with minimally invasive surgery, less blood loss, and shorter rehabilitation period.[5-8]

The early designs of UKA had a metal back and fixed polyethylene component. Early results were not satisfactory due to unbalanced bearing surfaces, use of a thin and fixed polyethylene component, and improper criteria for patient selection.[9-11] Refinement of patient selection criteria and advances in implant technology have resulted in significant improvements in implant survival and better functional results.[12,13]

Conflicting results with early designs of the Oxford UKA were reported.[14-19] In an analysis of UKA operations included in the Swedish Knee Arthroplasty Register between 1986 and 1995, it was concluded that most of the failures following UKA were observed in the early postoperative period.[20] There are only a few studies reporting the long-term clinical results and survival rates of the Oxford phase 3 UKA; most of the studies report short- and mid-term results.[5,8,21,22] In this study, we evaluated the short-term results of patients who underwent UKA with the Oxford cemented meniscal-bearing unicondylar knee prosthesis.

Patients and methods

The study included 38 patients (28 females, 10 males; mean age 67 years; range 56 to 75 years) who underwent UKA for isolated medial knee osteoarthritis in 2005 to 2007. At the time of surgery, there were 28 patients in the age group of 56-64 years and 10 patients in the age group of 65-75 years.

The patients were enrolled in the study based on the presence of the following criteria: persistent anterior knee pain unresponsive to conservative treatment, intact anterior cruciate ligament (ACL), correctable varus deformity, normal proximal tibial metaphyseal angle (absence of metaphyseal varus deformity), arthritis confined to the medial compartment, destruction involving only the cartilage (Ahlbäck grade 2),[23] and full cartilage depth in the lateral compartment. Patients who met these criteria underwent UKA with the Oxford phase 3 cemented meniscal-bearing unicondylar prosthesis (Oxford Partial Knee, Biomet Orthopedics, Bridgend, UK) with minimally invasive surgery. The presence of patellofemoral arthrosis was not regarded as a contraindication for the procedure. No age limits were defined for the patients.

Preoperatively, all the patients were routinely evaluated with weight-bearing anteroposterior (AP) radiographs of both knees. Additional varus stress radiographs were obtained in patients with narrowing of the medial compartment to evaluate the exact degree of medial arthrosis and to verify surgical indication (Fig. 1).[24]

All the patients had primary Ahlbäck grade 2 medial arthritis with no bone loss.[23] Proximal metaphyseal tibial angles were normal in all the patients; UKA was not considered in the presence of varus angulation in the proximal tibial metaphysis. The presence

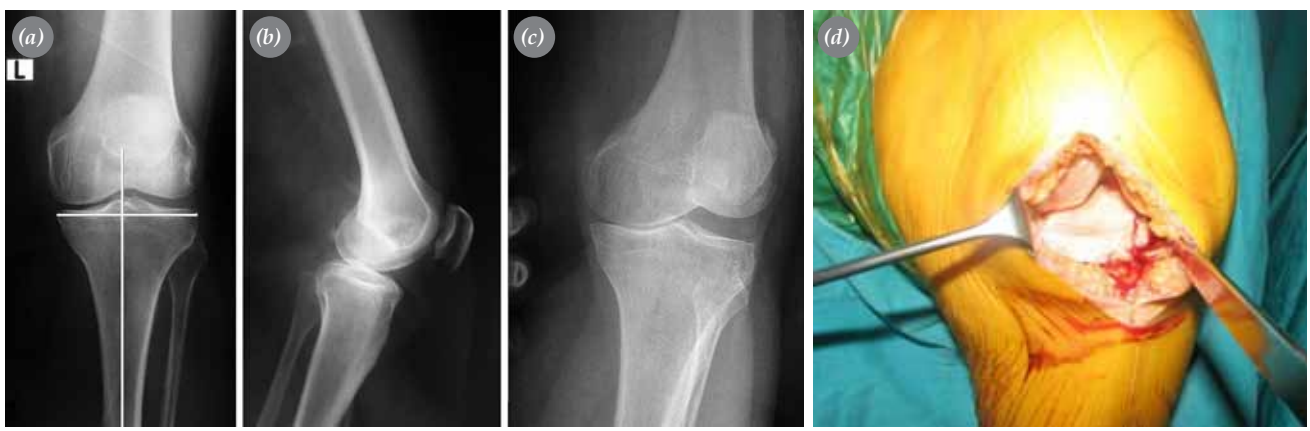

Fig. 1. Standing **(a)** anteroposterior and **(b)** lateral radiographs of a 55-year-old female patient with severe knee pain unresponsive to conservative treatment. **(c)** Varus stress radiograph of the patient showing closure of the medial articular space and cartilage loss. **(d)** Intraoperative appearance of articular destruction.

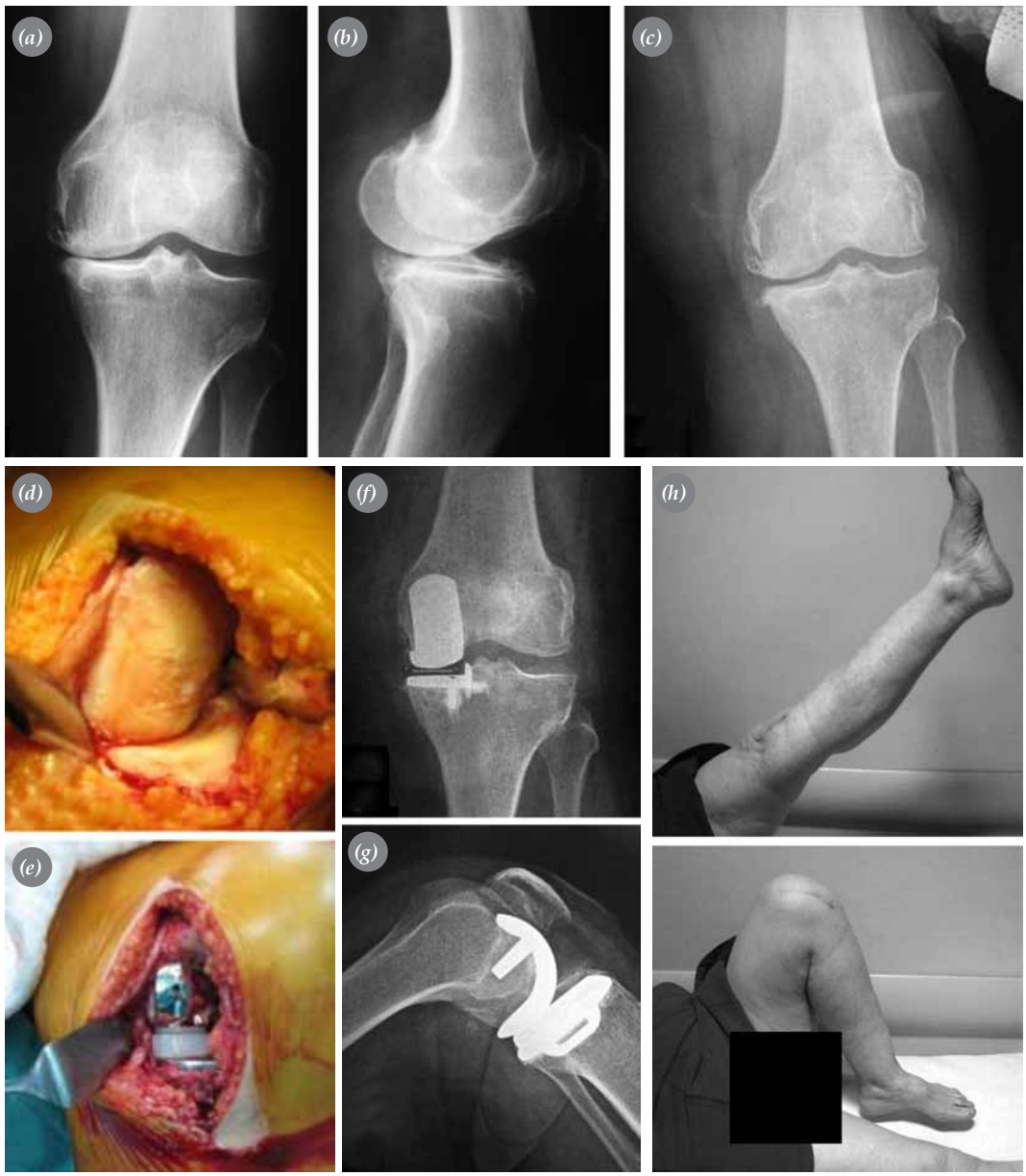

Fig. 2. Standing **(a)** anteroposterior and **(b)** lateral radiographs of a 62-year-old female patient. **(c)** Valgus stress radiograph was obtained to ensure the presence of correctable varus deformity and preservation of cartilage in the lateral compartment. **(d)** Intraoperative view showing articular destruction both on the tibial and femoral chondral surfaces. **(e)** Intraoperative view after fixation of both components before closure of the wound. **(f, g)** Anteroposterior and lateral radiographs and **(h)** functional result at the end of postoperative two years.

of correctable varus deformity and preservation of cartilage in the lateral compartment were confirmed by valgus stress AP knee radiographs (Fig. 2).[24]

None of the patients had a history of knee surgery for knee arthritis or symptoms of patellofemoral knee arthritis. Preoperatively, all the patients received 1 g of first-generation cephalosporin for antibiotic prophylaxis. Prophylactic low-molecular-weight heparin was used for prophylaxis against deep venous thrombosis for 10 days.

Surgical technique

The patients were prepared on a standard surgical table with the distal part of the table being removed and the knees being bent to at least 110 degrees of flexion. Under general or epidural anesthesia and tourniquet application, a minimally invasive, 8-10 cm

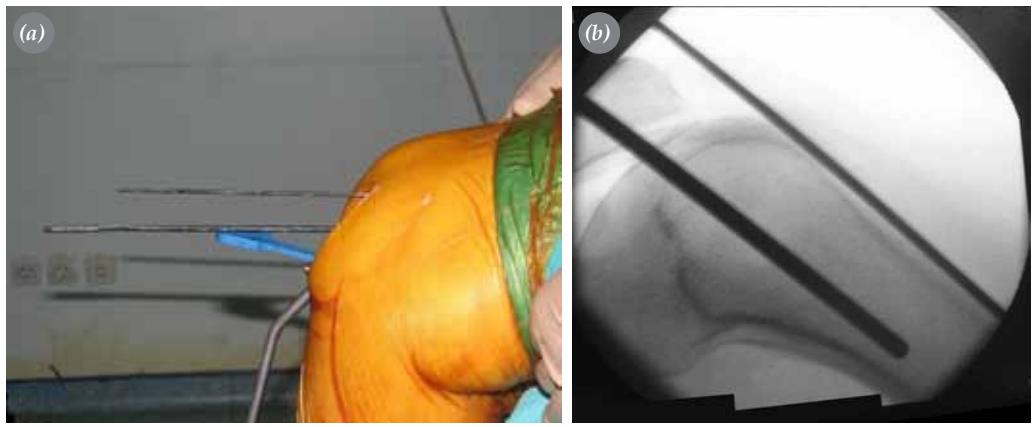

Fig. 3. **(a)** As an additional trick to the surgical technique described by the Oxford group, a guide wire is inserted submuscularly through the anterior femoral cortex to make sure that the femoral component is placed in neutral flexion/extension. Then, an intramedullary guide wire is inserted parallel to the first one in the lateral plane to guide femoral cutting. **(b)** Intraoperative fluoroscopic view. Fluoroscopic view was taken only in this patient for illustration; it was not routinely used in other operations.

long medial skin incision was made starting from the proximal pole of the patella and extending through the medial border to the tibial tubercle. A medial parapatellar arthrotomy was performed to confirm the integrity of the ACL. All patients who were thought to have an intact ACL in the preoperative radiographic evaluation were found to have an intact ACL intraoperatively. Following osteophyte removal and notchplasty, tibial and femoral cuts were performed using templates prepared preoperatively. As an additional trick to the surgical technique described by the Oxford group, a guide wire was inserted submuscularly through the anterior femoral cortex to prevent flexion or extension of the femoral component. Then, an intramedullary guide wire was inserted parallel to the first one in the lateral plane for femoral cutting (Fig. 3). The patella was not dislocated to avoid any disruption of knee alignment which might result in improper cutting. The femoral and tibial components were implanted using bone cement after balancing flexion and extension gaps. The mobile meniscal-bearing polyethylene was implanted and the wound was closed after tourniquet removal, bleeding control, and placement of suction drains.

Perioperative transfusion of packed erythrocytes was not necessary in any of the patients. Following removal of suction drains on the first postoperative day, active knee range of motion exercises were encouraged and the patients were mobilized with partial weight-bearing using crutches. Climbing stairs was allowed on the third postoperative day and the patients were discharged on the fourth postoperative day.

The patients were scheduled to a standardized follow-up protocol consisting of radiographic and clinical evaluations at monthly visits for the first three months, biannual visits up to 24 months, and annual controls thereafter. The mean follow-up period was 24 months (range 18 to 32 months). The results were assessed preoperatively and at final controls according to the Knee Society clinical and functional rating system.[25] Postoperative radiographic evaluations were made on standing AP radiographs based on the criteria previously defined.[26] Preoperative and postoperative data were compared using the dependent t-test, with the significance level being set at 0.05.

Results

The mean preoperative active flexion of the knees was 121.8° (range 110° to 130°), being within the range of 110° to 119° in 20 patients, and 120° to 130° in 18 patients. At final controls, the mean active flexion significantly increased to 130.9° (range 120° to 140°) ($p<0.05$). There was no limitation in knee extension both pre- and postoperatively.

The mean preoperative and postoperative Knee Society clinical scores were 64.6 (range 47 to 80) and 97.5 (range 89 to 100), and the mean functional scores were 59.6 (range 45 to 80) and 92.1 (range 70 to 100), respectively. Improvements in the clinical and functional scores were significant ($p<0.05$). At final con-

trols, all of the patients had an excellent clinical score, while functional scores were excellent in 27 patients (71.1%) and good in 11 patients (28.9%).

Postoperative radiographic measurements showed that the position of the femoral components was within acceptable ranges in all the patients with a mean of 3° valgus (range 5° valgus to 8° varus) and 0.5° extension (range 3° extension to 2° flexion). The positioning of the femoral components in relation to the mechanical axis was central in 30 patients and 2-mm lateral (range 2 mm medial to 4 mm lateral) in eight patients. There was no posterior protrusion of the femoral component.

The position of the tibial components was also within acceptable ranges in all the patients with a mean of 1.5° varus (range 2° varus to 2° valgus) and a mean posterior inclination of 6.2° (range 5° to 7°). All the tibial components showed full congruency with the medial, lateral, anterior, and posterior planes, except for one which had a 4-mm undersizing in the anterior plane. The polyethylene insert was central and parallel to the tibial component in all the patients. No osteophytes or cement debris that might lead to impingement were observed in any of the patients. All the components remained in position until the final controls.

Complications such as insert dislocation, infection, pulmonary embolism, deep venous thrombosis, or iatrogenic neurovascular injury were not observed. None of the patients required revision surgery.

Discussion

The early results of UKA in 1970s were disappointing.[9,10] However, successful results have been reported in recent studies and UKA has regained popularity.[5,8,18,21,27-32] Ten-year survival rates of UKA have been reported as 85% to 98% in many studies.[11-13,16,33,34] Improvements in prostheses design and technology, proper patient selection, and better surgical technique have been shown to be effective in obtaining successful results.[11,27-29,32]

One distinguishing feature of the Oxford phase 3 unicompartmental knee prosthesis is the wider articulating surface of the polyethylene insert, aiming to decrease stress on the prosthesis that would result in less wear.[35] Clinical and experimental studies showed less polyethylene wear with more congruent inserts.[36,37] Pandit et al.[8] reported the mean knee flexion as 133° and survival as 97.3% at the end of a five-year follow-up of patients undergoing the Oxford phase 3 UKA. In three other applications of the Oxford phase 3 UKA, the mean knee flexion increased from 117° to 131°,[37] from 106.4° to 117.4°,[5] and from 128.8° to 130.4°,[21] respectively. In these studies, the mean knee and functional scores improved within the range of 37 to 94, and 48.7 to 94, respectively.[5,21,37] Price et al.[34] compared the recovery rates following three arthroplasty techniques and found that the mean recovery rate after the Oxford phase 3 UKA was three times as fast as after total knee arthroplasty, and twice as fast as after the Oxford phase 2 prosthesis. In our study, after the Oxford phase 3 UKA, the mean active knee flexion increased from 121.8° to 130.9°, with significant improvements in the mean knee score from 64.4 to 97.5 and in functional score from 59.6 to 92.1. Clinical and functional results were excellent or good in all the patients.

Appropriate patient selection has been shown to be one of the most important factors to obtain good results.[12,28,32] Many criteria have been described for patient selection. The criteria proposed by Carr et al.[22] include the following: the presence of correctable varus deformity, intact ACL, absence of degenerative signs in the lateral compartment on standing AP radiographs, absence of tenderness over the lateral compartment, and minimal or no clinical and radiographic signs of patellofemoral arthritis. White et al.[38] described this pathology as anteromedial arthritis. According to the Oxford group, ideal candidates for unicompartmental arthroplasty are those having a combination of the following: isolated medial compartmental arthrosis, intact ACL, flexion contracture of less than 15 degrees, intact lateral compartment cartilage, correctable intra-articular varus deformity, and no history of inflammatory diseases including rheumatoid arthritis.[39]

The presence of patellofemoral arthritis does not constitute a contraindication for UKA.[7,39] In our study, patients for whom UKA was considered were those having severe knee pain unresponsive to conservative treatment, an intact ACL, correctable varus deformity, normal proximal tibial metaphyseal angle, osteoarthritis confined to the medial compartment involving only the cartilage (Ahlbäck grade 2), at least 110 degrees of knee flexion, and no flexion contracture. Patients with an abnormal proximal tibial metaphyseal angle (metaphyseal varus deformity) were

excluded. The presence of patellofemoral arthritis was not accepted as a contraindication.

Additional varus stress radiographs to standing AP radiographs have been shown to be useful to demonstrate the actual degree of articular cartilage loss in patients unresponsive to conservative treatment.[24,39] Our intraoperative observations support the efficacy of obtaining preoperative varus stress radiographs to estimate the extent of cartilage loss.

This group of patients having destruction limited only to the cartilage level without fixed soft tissue contracture or bone deformity are not very common. These patients have normal or near-normal knee range of motion, which has a favorable role in postoperative functional results.

Another important factor for successful results following UKA is strict adherence to the surgical technique. Any surgical mistake is irreversible and conversion to total knee arthroplasty may be inevitable. Poor results have been linked to poor patient selection, improper surgical technique, insufficient implant fixation, malalignment of the components, improper polyethylene thickness, and lack of experience.[9,21,40,41] It should be recalled that release of the medial collateral ligament may result in overcorrection which in turn leads to poor results.[16] Release of the medial collateral ligament may also cause spread of arthritis to other compartments and dislocation of the polyethylene insert.[33] Notchplasty has been recommended to prevent chronic irritation of the ACL.[17,42] Excessive tibial cut may lead to failure of the tibial component and thus poor functional results.[17,42] Meticulous care must be taken to fix the implants in proper alignment.[43] Extension and flexion gaps should be balanced and mechanical alignment should be restored to have a stable knee. It has been emphasized that the best results following UKA would be obtained in patients whose components are placed central or slightly medial to the mechanical axis, and over- or undercorrection would result in implant failure.[7,33,42] Complications observed following the Oxford phase 3 UKA are mainly peculiar to the procedure itself. Wear and fracture of the polyethylene insert are rare. Failure of the tibial component is less frequent compared to prostheses with a fixed bearing polyethylene insert.[33] In our study, placement of the components conformed to the radiographic criteria of the Oxford group and all the components remained in position at final controls. We believe that proper application of the surgical technique plays a major role in achieving good results.

Although medial compartment arthritis is seen at any age, it is more common in middle-aged patients whose activity levels are higher than those of elderly patients. There is no consensus in the literature on age limits for UKA. Poor results have been reported in young and active patients.[11,40] Many studies reported successful results in middle-aged patients.[5,6,11,30] In our study, the mean age was 67 years (range 56-75 years) and there were 28 patients in the age group of 56-64 years and 10 patients in the age group of 65-75 years. During a mean follow-up of 24 months (range 18 to 32 months), no complications were observed in this age group.

Our study has two limitations. The main limitation is that it has a relatively short follow-up period. Retrospective design of the study may be considered another limitation. The main strength of this study is that it is one of the few reports regarding UKA applications in our country.

In conclusion, our findings show that excellent results can be obtained with the Oxford phase 3 unicompartmental knee prosthesis with proper patient selection and strict adherence to the surgical technique. It is clear that studies with larger groups of patients and longer follow-up periods would provide more definite answers regarding the pros and cons of this method.

References

1. Çullu E, Aydoğdu S, Alparslan B, Sur H. Tibial slope changes following dome-type high tibial osteotomy. Knee Surg Sports Traumatol Arthrosc 2005;13:38-43.
2. Kesmezacar H, Erginer R, Ögüt T, Seyahi A, Babacan M, Tenekecioğlu Y. Evaluation of patellar height and measurement methods after valgus high tibial osteotomy. Knee Surg Sports Traumatol Arthrosc 2005;13:539-44.
3. Tokgözoğlu M, Acaroğlu E, Alpaslan AM. Gonartroz tedavisinde yüksek tibial osteotominin yeri. Ortopedi Travmatoloji Rehabilitasyon Dergisi 1988;3:152-8.
4. Güçlü B, Güzel B, Başarır K, Erdemli B, Çetin I. Midterm results of total knee arthroplasty in degenerative knee joint diseases with severe deformity. [Article in Turkish] Acta Orthop Traumatol Turc 2008;42:1-9.
5. Aslan H, Ersan O, Baz AB, Duman E, Aydın E, Ateş Y. Midterm results of Oxford phase 3 unicondylar knee arthroplasty for medial osteoarthritis. [Article in Turkish]

Acta Orthop Traumatol Turc 2007;41:367-72.
6. Laurencin CT, Zelicof SB, Scott RD, Ewald FC. Unicompartmental versus total knee arthroplasty in the same patient. A comparative study. Clin Orthop Relat Res 1991;(273):151-6.
7. Emerson RH Jr, Higgins LL. Unicompartmental knee arthroplasty with the Oxford prosthesis in patients with medial compartment arthritis. J Bone Joint Surg [Am] 2008; 90:118-22.
8. Pandit H, Jenkins C, Barker K, Dodd CA, Murray DW. The Oxford medial unicompartmental knee replacement using a minimally-invasive approach. J Bone Joint Surg [Br] 2006; 88:54-60.
9. Laskin RS. Unicompartmental tibiofemoral resurfacing arthroplasty. J Bone Joint Surg [Am] 1978;60:182-5.
10. Insall J, Walker P. Unicondylar knee replacement. Clin Orthop Relat Res 1976;(120):83-5.
11. Marmor L. Unicompartmental knee arthroplasty. Ten- to 13-year follow-up study. Clin Orthop Relat Res 1988;(226):14-20.
12. 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; 86:1931-5.
13. Berger RA, Nedeff DD, Barden RM, Sheinkop MM, Jacobs JJ, Rosenberg AG, et al. Unicompartmental knee arthroplasty. Clinical experience at 6- to 10-year follow-up. Clin Orthop Relat Res 1999;(367):50-60.
14. Rajasekhar C, Das S, Smith A. Unicompartmental knee arthroplasty. 2- to 12-year results in a community hospital. J Bone Joint Surg [Br] 2004;86:983-5.
15. Keys GW, Ul-Abiddin Z, Toh EM. Analysis of first forty Oxford medial unicompartmental knee replacement from a small district hospital in UK. Knee 2004;11:375-7.
16. Murray DW, Goodfellow JW, O'Connor JJ. The Oxford medial unicompartmental arthroplasty: a ten-year survival study. J Bone Joint Surg [Br] 1998;80:983-9.
17. Vardi G, Strover AE. Early complications of unicompartmental knee replacement: the Droitwich experience. Knee 2004;11:389-94.
18. Vorlat P, Putzeys G, Cottenie D, Van Isacker T, Pouliart N, Handelberg F, et al. The Oxford unicompartmental knee prosthesis: an independent 10-year survival analysis. Knee Surg Sports Traumatol Arthrosc 2006;14:40-5.
19. Robertsson O, Knutson K, Lewold S, Lidgren L. The routine of surgical management reduces failure after unicompartmental knee arthroplasty. J Bone Joint Surg [Br] 2001; 83:45-9.
20. Lewold S, Goodman S, Knutson K, Robertsson O, Lidgren L. Oxford meniscal bearing knee versus the Marmor knee in unicompartmental arthroplasty for arthrosis. A Swedish multicenter survival study. J Arthroplasty 1995;10:722-31.
21. Kim KT, Lee S, Park HS, Cho KH, Kim KS. A prospective analysis of Oxford phase 3 unicompartmental knee arthroplasty. Orthopedics 2007;30(5 Suppl):15-8.
22. Carr A, Keyes G, Miller R, O'Connor J, Goodfellow J. Medial unicompartmental arthroplasty. A survival study of the Oxford meniscal knee. Clin Orthop Relat Res 1993;(295):205-13.
23. Ahlbäck S. Osteoarthrosis of the knee: a radiographic investigation. Acta Radiol 1968;Suppl 277:7-72.
24. Gibson PH, Goodfellow JW. Stress radiography in degenerative arthritis of the knee. J Bone Joint Surg [Br] 1986; 68:608-9.
25. Ewald FC. The Knee Society total knee arthroplasty roentgenographic evaluation and scoring system. Clin Orthop Relat Res 1989;(248):9-12.
26. Goodfellow JW, Tibrewal SB, Sherman KP, O'Connor JJ. Unicompartmental Oxford Meniscal knee arthroplasty. J Arthroplasty 1987;2:1-9.
27. Keblish PA, Briard JL. Mobile-bearing unicompartmental knee arthroplasty: a 2-center study with an 11-year (mean) follow-up. J Arthroplasty 2004;19(7 Suppl 2):87-94.
28. Bert JM. Unicompartmental knee replacement. Orthop Clin North Am 2005;36:513-22.
29. Iorio R, Healy WL. Unicompartmental arthritis of the knee. J Bone Joint Surg [Am] 2003;85:1351-64.
30. Svärd UC, Price AJ. Oxford medial unicompartmental knee arthroplasty. A survival analysis of an independent series. J Bone Joint Surg [Br] 2001;83:191-4.
31. Deshmukh RV, Scott RD. Unicompartmental knee arthroplasty for younger patients: an alternative view. Clin Orthop Relat Res 2002;(404):108-12.
32. Marcacci M, Iacono F, Zaffagnini S, Nofrini L, Neri MP, Russo A, et al. Minimally invasive unicompartmental knee arthroplasty in varus knee. Techniques in Knee Surgery 2004;3:259-66.
33. Emerson RH Jr, Hansborough T, Reitman RD, Rosenfeldt W, Higgins LL. Comparison of a mobile with a fixed-bearing unicompartmental knee implant. Clin Orthop Relat Res 2002;(404):62-70.
34. Price AJ, Webb J, Topf H, Dodd CA, Goodfellow JW, Murray DW; Oxford Hip and Knee Group. Rapid recovery after Oxford unicompartmental arthroplasty through a short incision. J Arthroplasty 2001;16:970-6.
35. O'Connor JJ, Goodfellow JW. Theory and practice of meniscal knee replacement: designing against wear. Proc Inst Mech Eng H 1996;210:217-22.
36. Argenson JN, O'Connor JJ. Polyethylene wear in meniscal knee replacement. A one to nine-year retrieval analysis of the Oxford knee. J Bone Joint Surg [Br] 1992;74: 228-32.
37. Rees JL, Price AJ, Beard DJ, Dodd CA, Murray DW. Minimally invasive Oxford unicompartmental knee arthroplasty: functional results at 1 year and the effect of surgical inexperience. Knee 2004;11:363-7.
38. White SH, Ludkowski PF, Goodfellow JW. Anteromedial osteoarthritis of the knee. J Bone Joint Surg [Br] 1991; 73:582-6.
39. Price AJ, Dodd CA, Svard UG, Murray DW. Oxford medi-

al unicompartmental knee arthroplasty in patients younger and older than 60 years of age. J Bone Joint Surg [Br] 2005;87:1488-92.

40. Engh GA, McAuley JP. Unicondylar arthroplasty: an option for high-demand patients with gonarthrosis. Instr Course Lect 1999;48:143-8.
41. Schai PA, Suh JT, Thornhill TS, Scott RD. Unicompartmental knee arthroplasty in middle-aged patients: a 2- to 6-year follow-up evaluation. J Arthroplasty 1998; 13:365-72.
42. Kennedy WR, White RP. Unicompartmental arthroplasty of the knee. Postoperative alignment and its influence on overall results. Clin Orthop Relat Res 1987;(221):278-85.
43. Shakespeare D, Ledger M, Kinzel V. Accuracy of implantation of components in the Oxford knee using the minimally invasive approach. Knee 2005;12:405-9.