Unicondylar Knee Arthroplasty: Past and Present

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educational objectives

As a result of reading this article, physicians should be able to:

1. Describe the historical development of unicondylar knee arthroplasty (UKA).
2. Recognize the desirable features of a unicondylar prosthesis.
3. Identify the ideal patient for UKA.
4. Summarize the principles of the unicondylar surgical procedure.

Unicondylar knee arthroplasty (UKA) is a surgical procedure that resurfaces the medial or lateral compartment of the tibiofemoral joint of the knee. The procedure is sometimes used as an alternative to high tibial osteotomy (HTO) or total knee arthroplasty (TKA) when only one side of the knee is involved.1-7

Surgeons have been interested in UKA because the prosthesis itself was designed to rest on the subchondral bone without interfering with the cruciate ligaments or major capsular structures of the knee joint.8-10 Theoretically, all UKAs are designed to yield a knee with more normal kinematics than TKA.11-13 The UKA design should allow patients to retain more normal proprioception and stability of the remaining knee joint. However, the clinical results have been controversial and many orthopaedic surgeons disregarded this procedure because of previous poor results.14-19

Several recent publications have demonstrated that long-term survivorship of UKA is about the same as that recorded in TKA.17-19 The development of better implants, appropriate patient selection, the use of thicker and better polyethylene, and better surgical technique has contributed to the improved outcomes. With the use of the minimally invasive surgical technique instead of a standard median parapatellar approach with patellar eversion, UKA can facilitate earlier postoperative range of motion and ambulation with a shorter hospital stay and a shorter period of rehabilitation.9,20 The indications for surgery have been extended to the younger age group and this has led to comparisons between UKA and HTO.5,6

DEVELOPMENT OF UKA IMPLANTS

The Polycentric knee prosthesis was designed by Gunston21 in 1968 as a replacement for both the medial and lateral compartments of the knee. The component design included significant constraint. The radius of the femoral runner and the tibial polyethylene were identical and the tibial component had a narrow mediolateral dimension. Gunston’s prosthesis fostered some of the early ideas concerning UKA. Marmor8 introduced the first unicompartmental knee prosthesis in 1973. The Marmor knee was originally designed to mimic the resurfacing concepts of Gunston and addressed both compartments of the knee. Marmor subsequently used the implant to resurface a single side of the knee and published some of his results in the late 1970s. The prosthesis had a narrow femoral runner with a single peg and an inlay tibial component. In Eu-

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The initial high failure rate in the early reports was related to improper patient selection, incorrect surgical technique, and poor implant design.

**TYPE OF FIXATION IN UKA**

Most unicondylar devices are fully cemented on both the femoral and tibial sides. The tibial components have been reported to have some increased loosening when they are all polyethylene with a smooth under surface. Cementless designs have been fraught with loosening and sinkage. Bernasek et al. reported on a series of 28 UKAs that only showed fibrous ingrowth into the component surfaces. Bert and Smith reported on 31 metal backed, cementless UKAs and found that 19% of the failures were secondary to lack of bone ingrowth with subsequent loosening. However, Magnussen and Bartlett reported good results with the PCA unicondylar prosthesis in 51 knees with a cementless technique. There were 5 failures in the series; and they were a result of technical errors, inappropriate patient selection, and synovitis. The literature tends to support cemented techniques for better results with respect to loosening.

**DEVELOPMENT OF SURGICAL TECHNIQUE FOR UKA**

The original surgical approach for this procedure was a standard medial or lateral parapatellar arthroscopy with associated eversion of the patella and division of the quadriceps tendon. This technique is identical to that of TKA and the postoperative rehabilitation is essentially the same. Subsequently, the concept of minimally invasive surgery was introduced into orthopedic surgery with a less invasive technique for the partial replacement. Minimally invasive UKA can be performed with an 8-cm long incision in combination with a full range of specifically designed instruments. The new surgical technique and instrumentation leads to less invasion of the extensor mechanism. The patella is not everted and the suprapatellar synovial pouch remains untouched. Reppici introduced the minimally invasive technique and he has reported his eight-year follow-up with only a 9% failure rate.

**RESULTS OF UKA**

Results of UKA should be separated into two groups: UKA reports using standard TKA surgical techniques and UKA reports that included changes specific to the different implant and to the different surgery. The initial high failure rate in the early reports was related to improper patient selection, incorrect surgical technique, and poor implant design. Since 1996, the publications for UKA have shown a steady improvement in the results.
with a total failure rate of 12%. Many surgeons concluded from these studies that UKA was not a predictable operation and that the results of UKA were not as good as those of TKA.

Towards the end of the 1980s, some favorable results began to appear. Thornhill reported 92% excellent results at 42-month follow-up. Capra and Fehring had a 93% survivorship at 10 years in 52 UKAs. Scott et al reviewed 100 UKAs after 8- to 12-year follow-up and reported an 85% survivorship rate. A multicenter study of the Marmor prosthesis in 294 UKAs reported a 91.4% survivorship at 10 years. All of the improved results stressed the importance of proper patient selection and careful surgical technique with minimal correction of the tibiofemoral angle. Although excellent clinical results began to appear, the early generations of UKA did not have the long-term survivorship of the TKAs. Unicondylar knee arthroplasty results remained in question. Repicci is a strong supporter of UKA, however, he reports that the implant is a time limited procedure before TKA.

RESULTS OF UKA USING A MINIMALLY INVASIVE TECHNIQUE

With the combination of long-term favorable results and the introduction of the minimally invasive procedure, UKA has undergone somewhat of a rebirth. Repicci and Eberle compared minimally invasive UKA with conventional UKA and showed that minimally invasive UKA provided much earlier ambulation and weight bearing with decreased postoperative pain. Patients gained 90° of motion with less need for physical therapy and the operative blood loss was <200 cc. Romanowski and Repicci reported their 8-year follow-up of 136 minimally invasive UKAs on 126 patients. Eighty-six percent of patients had good to excellent results. Revision was performed in 10 patients due to advancement of disease in the remaining compartments in 5 patients, surgical error in 3, poor pain relief in 1, and fracture in 1. The authors do not discuss the details of the surgical errors. Price et al documented that the accuracy of implantation with a shorter incision was the same as that with the standard open technique.

UKA VERSUS TKA

In the late 1980s the results of the long-term follow-up of UKA were not as good as those reported with TKA. Many surgeons refrained from using the partial knee replacements because of the unpredictability of the result. The surgical technique for TKA continued to improve and more instruments were introduced to increase the accuracy of the operative procedure. Surgeons were very familiar with the principles of TKA and learned how to balance ligaments, correct alignment, and deal with deformity. In the early phases of the UKA development, many of the principles of TKA were brought over to the procedure and contributed to the failures. In TKA, the knee alignment is corrected to an anatomic 6° or 7° of valgus. In UKA, this leads to excessive medial compartment tightness and to overload of the opposite, lateral compartment. The varus knee for the UKA should be left in neutral or a few degrees of varus. In TKA, a flexion contracture can be readily corrected with additional resection of both femoral condyles. In UKA, resection of the single distal femoral condyle will help to correct the flexion contracture but also changes the distal anatomic femoral valgus. Ligament releases in UKA are not as predictable as in TKA because only one compartment is being replaced in the UKA and the forces on the opposite compartment are more difficult to balance.

The UKA also has a residual patellofemoral and contralateral femorotibial joint that has not been replaced. These remaining areas can contribute to postoperative pain and may compromise the result. However, in the early period after UKA, the advantages of UKA over TKA are quite clear. Patients tend to flex the knee more rapidly, their proprioception is better, and they walk more comfortably. Rougraff et al compared 120 UKAs with 81 TKAs and reported that the UKA patients had better ROM and ambulatory function than the TKA patients. There was no statistically significant difference in aseptic loosening between the two patient groups. Laurencin et al studied 23 patients who underwent UKA on one side and TKA on the other during the same hospital stay. He reported better early ROM and better pain control after surgery in the knee with the UKA. In addition, patients felt that the knee with UKA was more natural. Newman et al showed that the recovery time and the length of the hospital stay of pa-
Table 1

Reported Long-term Survivorship of Recent Studies

<table>
<thead>
<tr>
<th>Authors</th>
<th>Special Patient Selection</th>
<th>Prosthesis</th>
<th>Start</th>
<th>Study</th>
<th>Compartment</th>
<th>Mean Age (Range)</th>
<th>Study Years (Range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cartier et al16</td>
<td>Accepted AP subluxation, chondrocalcinosis &amp; age &lt;60 y</td>
<td>Marmor</td>
<td>197/207</td>
<td>54/60</td>
<td>53 medial, 7 lateral</td>
<td>65 (28-82)</td>
<td>12 (10-18)</td>
</tr>
<tr>
<td>Ansari et al17</td>
<td>Conventional criteria*</td>
<td>St Georg</td>
<td>368/461</td>
<td>NA/437</td>
<td>All medial</td>
<td>70 (46-93)</td>
<td>4 (1-17)</td>
</tr>
<tr>
<td>Murray et al18</td>
<td>Accepted patellofemoral arthritis</td>
<td>Oxford</td>
<td>114/144</td>
<td>85/109</td>
<td>All medial</td>
<td>70.7 (34.6-90.6)</td>
<td>7.6 (4.8-13.8)</td>
</tr>
<tr>
<td>Tabor &amp; Tabor19</td>
<td>Accepted body weight &gt;180 lbs &amp; age &lt;60 y</td>
<td>Marmor</td>
<td>63/74</td>
<td>58/67</td>
<td>61 medial, 6 lateral</td>
<td>61 (41-80)</td>
<td>9.7 (5-20)</td>
</tr>
<tr>
<td>Bert10</td>
<td>Conventional criteria*</td>
<td>Biomet</td>
<td>100/100</td>
<td>95/95</td>
<td>94 medial, 6 lateral</td>
<td>62.5 (48-69)</td>
<td>10.1 (9.5-12.2)</td>
</tr>
<tr>
<td>Berger et al17</td>
<td>Accepted &lt; Outerbridge’s grade III of other compartments</td>
<td>Miller-Galante</td>
<td>51/62</td>
<td>40/51</td>
<td>3 lateral</td>
<td>(51-84)</td>
<td>(6-10)</td>
</tr>
<tr>
<td>Squire et al18</td>
<td>Accepted obesity, activity, age &lt;60 y, subluxation</td>
<td>Marmor</td>
<td>103/140</td>
<td>34/48</td>
<td>125 medial, 15 lateral</td>
<td>68 (51-83)</td>
<td>&gt;15</td>
</tr>
<tr>
<td>Svard &amp; Price16</td>
<td>Accepted patellofemoral arthritis, chondrocalcinosis, and age &lt;60 y</td>
<td>Oxford</td>
<td>103/124</td>
<td>60/74</td>
<td>All medial</td>
<td>69.6 (50.7-85.7)</td>
<td>12.5 (10.1-15.6)</td>
</tr>
</tbody>
</table>

Abbreviations: BMI = body mass index, HSS = Hospital for Special Surgery, NA = not available, OA = osteoarthritis, and PE = pulmonary embolism.
*Patient selection according to Kostin and Scott including: age >60 years with low demand for activity, weight <180 lbs, minimum pain at rest, >90° arc of flexion, angular deformity <10°-15°, no opposite or patellofemoral compartment erosion, osteoarthritis or avascular necrosis.

Patients who underwent UKA was shorter than that in TKA. Weale et al16 reported that UKA patients were better able to descend stairs than the TKA patients; however, there was no significant difference in the final pain and functional outcome. In addition, revision of a UKA to a TKA has results similar to a primary TKA and has been reported to be an easier procedure than the typical revision TKA.41

UKA Versus HTO

Unicondylar knee arthroplasty has a higher rate of initial success and fewer operative complications when compared to high tibial osteotomy (HTO). A retrospective study comparing 49 HTOs and 42 UKAs with the same criteria for surgery5 showed that at 5- to 10-year follow-up, 76% of UKA patients still had good results and only 43% of HTO patients had the same result. In addition, 10 HTOs had gone on to TKA revision. A match-paired study of 20 patients6 reported that the UKA group had better clinical results than the osteotomy group with respect to rehabilitation 6 months after the index surgical procedure.

A long-term comparative study between UKA and HTO7 demonstrated that UKA provided superior early and long-term results than that of osteotomy.

Unicondylar knee arthroplasty can be performed as a bilateral procedure with early ambulation and ROM. While HTO can also be performed as a bilateral procedure, the morbidity is greater and rehabilitation is slower. Unicondylar knee arthroplasty is more desirable for the varus knee in the female population because the HTO leaves the patient with a visible, valgus cosmetic deformity. Although a successful UKA can eliminate pain and improve the patient’s function, heavy labor and high impact athletic activities are not encouraged. High tibial osteotomy allows a patient to perform more aggressive activities.

Gill et al44 looked at the results of TKA after UKA and after HTO. He found that there was more bone loss with the UKA revision and that the HTO revision had a better Knee Society Score at an average of 3.8 years after the surgery. Meding reported on TKA after HTO in 39 bilateral TKAs performed an average of 8.7 years after the HTO. He concluded that the clinical and radiographic results were no different between the two knees. More knees were free of pain in the group without a previous HTO but the differences were not statistically significant.
<table>
<thead>
<tr>
<th>Criteria for Failure</th>
<th>Survival Rate</th>
<th>Clinical Results</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>All revision</td>
<td>10 y, 93%</td>
<td>75% excellent, 20% good</td>
<td>Lateral retanacular release in all cases. Results: younger group=older group</td>
</tr>
<tr>
<td>All revision or need revision</td>
<td>10 y, 88%</td>
<td>92% good to excellent</td>
<td>Most common cause of failure: increased OA on opposite site. Single surgeon, no PE failure &amp; no tibial loosening</td>
</tr>
<tr>
<td>All revision</td>
<td>10 y, 98%</td>
<td>NA</td>
<td>Single surgeon, no PE failure, &amp; no tibial loosening</td>
</tr>
<tr>
<td>All revision</td>
<td>10 y, 84%</td>
<td>84% excellent</td>
<td>Age &lt;60 y, same results</td>
</tr>
<tr>
<td>All revision</td>
<td>15 y, 79%</td>
<td>8% good</td>
<td>BMI &gt;30, same results</td>
</tr>
<tr>
<td>All revision</td>
<td>10 y, 87.4%</td>
<td>Minimum HSS score from 77</td>
<td>10% were cementless and 20% failure of cementless group</td>
</tr>
<tr>
<td>All revision</td>
<td>10 y 98%</td>
<td>20% good</td>
<td>Most common cause of failure: increased OA on opposite site</td>
</tr>
<tr>
<td>All revision</td>
<td>22 y, 84%</td>
<td>Average KSS score=85 and average functional score=71</td>
<td></td>
</tr>
<tr>
<td>All revision</td>
<td>10 y, 95%</td>
<td>NA</td>
<td>Independent series</td>
</tr>
</tbody>
</table>

The result of a revision of a UKA to a TKA is dependent on the mode of failure of the primary UKA.40,44 If the implant remains intact and advancing arthritis in the opposite compartment or the patellofemoral joint is the reason for failure, the revision is not very difficult. If the implant loosens with significant bone destruction, the revision will be difficult and will have to address significant bone loss.

**Patient Selection for UKA**

Initially, UKA was chosen for patients aged ≥60 years with a sedentary lifestyle.8,17,30,45 As the procedure has improved, it has been applied to a younger age group with equal success.46 The patient's symptoms and physical findings should be isolated to one tibiofemoral compartment. The history must be thoroughly evaluated to ensure that there are no associated patellofemoral symptoms or symptoms in the opposite compartment. While stair climbing discomfort alone does not implicate the patellofemoral joint, if a patient reports increased pain with stair climbing, the surgeon should be wary of patellar involvement in the knee joint. The knee should have <15° of deformity in varus or valgus and <10° flexion contracture. Inflammatory or crystalline induced arthritis, anterior cruciate ligament (ACL) deficiency, advanced patellofemoral arthritis, knee subluxation, gross ligamentous laxity, and obesity are all relative contraindications to the procedure. However, if all of these guidelines are strictly followed, Stern et al47 showed that only 6% of patients will satisfy the criteria for the replacement.

As surgeons have gained experience with the procedure, the indications have been broadened. In the younger population it is best to adhere to the strict indications, and the results should be more predictable.46 In the older population, it is possible to accept some patellofemoral or opposite compartment radiographic findings for osteoarthritis as long as the patient does not report symptoms in those other areas and has no findings on physical examination.

**ACL Issue**

In a series of 103 UKAs, Goodfellow et al10 reported that 6 of 37 knees that had an abnormal ACL failed. The failure rate was 16.2% compared to 4.8% of the knees with an intact ACL. Chassin et al18 analyzed the gait pattern of patients with an intact ACL who underwent a medial UKA. He found that 7 of the 10 patients who were
studied had a normal biphasic flexion and extension moment pattern after UKA. He concluded that the biomechanics of the quadriceps mechanism is normal in the knee undergoing UKA with an intact ACL. Using three-dimensional in vivo kinematic studies in 20 knees, Dennis et al. 11 recently concluded that the kinematic results depend on the integrity of the ACL.

While some authors 8,23,48 believed that an intact ACL is a strict prerequisite for the procedure, Christensen 49 found that absence of the ACL was not a contraindication. He also stated that the effect of the absent ACL on sagittal instability was less pronounced in the arthritic knee than in the younger normal knee. The procedure could be performed with success as long as the collateral ligaments did not have significant attenuation. Laskin 19 questioned that loosening or abnormal wear of the polyethylene was associated with the absent ACL in UKA patients. He also emphasized that other factors such as the postoperative knee alignment could also have a role in the failures that were seen. The authors believe that some arthritic knees that have an absent ACL with minimal findings of laxity on physical examination are amenable to UKA.

**Obese Patients**

Scott et al. 21 found that increased body weight contributed to failure in UKA. He suggested that the best candidates should be <180 pounds. Heck et al. 35 agreed with Scott’s conclusions and proposed that failure was associated with patient body weight >82 kg (180 pounds). In contrast to these studies, reports with the Oxford meniscal bearing knee 18,38 indicate good to excellent long-term results with no contraindication concerning body weight. Tabor 39 reported a 17.7% failure rate for patients <180 pounds compared to 4.8% failure for patients >180 pounds. Using a body mass index (BMI) of ≥30 to define obesity, they found similar long-term outcomes for the obese and non-obese groups. The authors presently use a cut off of 250 pounds (114 kg) for the arthroplasty with the knowledge that the literature reports are mixed at best.

**Patellofemoral Arthritis**

Patellofemoral arthritis with its associated symptoms has been a common explanation for UKA failure. Marmor 30 reported that inappropriate placement or sizing of the femoral component could lead to impingement of the patellofemoral joint. Kozinn and Scott 45 have emphasized that pain at the patellofemoral joint is a relative contraindication for surgery. If there is exposed subchondral bone in the patellofemoral joint, they recommended total knee replacement. The Oxford group 10 has shown that there is no correlation between the state of the patellofemoral joint at operation and the clinical outcome. Furthermore, they reported no radiographic arthritic change of the patellofemoral joint 10 years after UKA. 50

Recently, a long-term follow-up of UKA demonstrated patellar impingement in 29% of unrevised UKA cases. 51 Degenerative changes of the patellofemoral joint also affected patient function, but the symptoms were less severe than in patients with patellar impingement.

The authors have performed 320 UKAs over the past four years and have had four conversions to TKA; two for advancing disease in the patellofemoral joint. If patients report significant symptoms related to the patellofemoral joint, UKA is contraindicated. The difficult patient presents with little or no symptoms but with radiographic findings of osteoarthritis in the joint. If the radiographs show total loss of the joint space, UKA is again contraindicated. If there is joint space remaining, the clinical decision will be a more difficult one.

**Lateral UKA**

Most reports of UKA included both medial and lateral replacements. There is a tendency to conclude that the results of the two are very similar. In Marmor’s series, 30 the results of 5 lateral UKAs were not different compared to 54 medial UKAs. Some authors 44,45 documented that lateral UKA had more predictable results than the medial UKA. The Oxford Group reported 5 bearing dislocations in 27 lateral compartment arthroplasties. 10 The same complication occurred in only 1 of 76 medial compartment arthroplasties. A radiographic study of the meniscal bearing knee 13 showed that the lateral mobile bearing unit moved more than the medial one in the sagittal plane. A later study from the same institution 52 demonstrated that the lateral UKA had a survival rate of only 67% at 10 years (using revision as the final endpoint). This implies that the meniscal bearing UKA is not suitable for lateral compartment replacement. However, Ohtera et al. 31 reported a satisfactory outcome in 38 lateral UKAs with 5-year follow-up using 4 different types of prostheses. In this series, only 18 knees were available for evaluation. They found that 89% of evaluated knees had satisfactory results in terms of function and pain relief without any radiolucent lines. Recently, Ashraf et al. 34 reported long-term results of 88 lateral UKAs with an average 9-year follow-up. The 10- and 15-year survival rates were 83% and 74% respectively. Lateral UKA can be as successful as medial UKA when the proper prosthesis and surgical techniques are chosen.

**UKA in the Younger Aged Group**

Initially, most series 17,23,30 selected patients for UKA who were aged >60 years with a sedentary life style. Because UKA was an attractive alternative to osteotomy or TKA in the middle-aged group and because it provided a reliable 8- to 10-year satisfactory result, Scott proposed an expansion of the indications for UKA to the younger age group with osteoarthritis, especially middle-aged women. A study of 28 knees from the same institution 55,56 with 2- to 6-year follow-up in patients aged <60 years, showed that 90% of patients had good to excellent results with respect to pain relief and function. They
also reported an improved average activity level according to the Tegner-Lysholm score. However, UKA in this age group was inferior to that of TKA in terms of revision. Carrier et al noted a difference in the younger-aged group and patients aged >60 years with long-term follow-up. Pennington's report also supports UKA in the age group <60 years.

**EARLY FAILURE OF UKA**

Patient selection, implant design, and surgical technique all contributed to the early failures of UKA.

**Implant Designs**

In a series of revisions of UKA in 29 patients, Barrett and Scott reported femoral component failures were related to the narrow runner design. The study on 3777 UKAs comparing the revision rate of the Porous-Coated Anatomic prostheses (PCA, Howmedica, Rutherford, NJ) to the Marmor and St Georg knees showed that the PCA prostheses had a 15% cumulative revision rate that was three times higher than the other two designs six years postoperatively. There was no difference between the Marmor and St Georg prostheses. Fifty percent of the PCA failure cases had femoral component loosening. These components used a single lug for fixation and were implanted in a cementless setting.

Bergenlé emphasized the effect of poor prosthetic design with a 28% rate of failure of the femoral component and excessive polyethylene wear in a series of 108 UKAs. Riebel et al conducted a biomechanical test on cadaveric limbs implanted with the PCA prosthesis and showed a high rate of early loosening due to shear at the bone-prosthesis interface. They showed that the design of the components has an effect on the clinical outcome.

**Polyethylene Issues**

According to Marmor's series, poor results were usually associated with the use of a 6-mm thick polyethylene insert. In his long-term follow-up, he recommended a minimum of 8-mm thickness with the widest possible tibial component to allow the prosthesis to seat on the peripheral cortical rim. Bartley et al reported that the wear pattern of polyethylene in UKA was characterized by delamination, pitting, peripheral tearing, deformation, and abrasion.

A retrieval study of Blunn et al concluded that the most severe type polyethylene wear in UKA was delamination. The short-term polyethylene failures were associated with the manufacturing process and specific prosthetic designs. The medium- and long-term failures were associated with high polyethylene conformity that restricted the rotation of the femoral component on the polyethylene. Delamination in a knee with laxity was due to wear toward the edges of the tibial component.

**The manufacturing of the polyethylene is improving and cross-linking processes are increasing the wear properties of the material.**

Progression of the osteoarthritis, subsidence of the tibial component, and attenuation or rupture of the ACL after surgery may all lead to secondary subluxation of the implants with subsequent increased contact stresses on the polyethylene. McMullen and Scott demonstrated that the pattern of polyethylene wear duplicated the preoperative wear pattern of the arthritic knee. To minimize this problem, they suggested using a thicker polyethylene especially at the anterior and peripheral margins. In addition to the polyethylene thickness, Palmer et al found that fusion defects in the polyethylene, increased rotational freedom of the knee, and reduced conformity in the design of the prosthesis were other possible causes of failure.

On the other hand, reports of polyethylene wear on meniscal bearing UKA have shown a low annual wear rate. A study on 23 retrieved polyethylene meniscal bearings from failed UKAs reported that the wear rate was 0.066 mm per year. Psychiyo et al in the study of 16 retrieved polyethylene inserts from the Oxford UKA, found that the average polyethylene wear rate was 0.036 mm per year. The amount of wear was not related to the thickness of the polyethylene insert. He concluded that congruent meniscal bearing polyethylene provided a negligible polyethylene wear rate, but great care was needed at implantation to avoid any impingement. Engin et al reported polyethylene cold flow on the back side of the insert in some metal-backed, modular tibial components and noted the amount of wear was related to the time after surgery. He also found that polyethylene buck side wear was related to delamination in load-bearing areas of thin polyethylene inserts. The manufacturing of the polyethylene is improving and cross-linking processes are increasing the wear properties of the material. Most authors believe that it is safer to use a thickness of at least 6 mm with conventional polyethylene.

**Surgical Technique**

In TKA it is important to correct the existing deformity in the coronal plane so that a 4° to 6° anatomic valgus is established with collateral ligament balance. In UKA the concepts are different because the surgery is only on one side of the joint. Squire reported that failures occurred from progressive arthrosis in the opposite compartment and he felt that this could be averted by avoiding over correction of the presenting deformity. Weale et al supported this concept by demonstrating a low incidence of progressive osteoarthritis in the opposite compartment with a minimum 5-year follow-up. Swank et al...
reported a 17% impending radiographic failure in a series of 82 UKAs with a minimum 4-year follow-up. He concluded that one of the major causes for the failure was progression of arthritis in the contralateral compartment.

The preoperative evaluation of the patient should include the standard four radiographs of the knee: the anteroposterior (AP) standing, lateral, tunnel, and patellar view. The posterior to anterior 30° flexed view is also helpful in documenting loss of joint space when the standard AP view fails to show this and there is significant clinical suspicion.

Unfortunately, there is no consensus on the amount of ideal correction of the preoperative deformity. Many of the authors who report a high success rate with long-term follow-up recommend not to overcorrect the preoperative alignment. In the medial UKA with preoperative varus, most of the reviews suggest an alignment of 0° with reference to the anatomical axis of the lower extremity or slightly less than 0° with reference to the mechanical axis. In the study by Kennedy and White90 on 100 UKAs, they reported that superior results were obtained when the postoperative mechanical axis of the operated limb fell in the center of the knee or slightly medial to the center. According to this study, in the varus knee, if the medial release was significant or excessive, it will produce a postoperative valgus knee. Table 2 summarizes the degree of correction and the radiographic arthritic changes in the opposite compartment as it is reported in the literature.97

Some authors suggest that the preoperative varus deformity should be passively correctable to neutral. A recent study on 40 medial UKAs with the mean follow-up of 6 years21 noted a seven-fold increase in the revision rate when the postoperative alignment was outside the desired range of 2° of anatomic varus to 6° of anatomic valgus.

Mallory and Dany37 reported 13 (31%) failures due to technique and prosthetic design in his series of 42 procedures with an average 67-month follow-up. Lewold et al93 showed that the 5-year cumulative UKA revision rate had been reduced from 11% to 5%. He compared the improvement in the UKA revision rate to the improvement in the TKA revision rate over the same period of time and showed a statistically significant difference between the two. The author concluded that the UKA results were secondary to better surgical technique, more precise instrumentation, and improved cementing procedures. The Swedish multi center study94 showed that the meniscal bearing knee had a higher revision rate than that of the fixed bearing design due to the increased demand for the surgical procedure. Barrett and Scott27 concluded that technical errors led to failure in 16 (55%) of their 29 patients. These studies and others indicate the
importance of understanding the principles of the surgical procedure and knowing the implant design.

**Radiographic Evaluation After UKA**

Component loosening on radiographic evaluation includes migration, cement fracture, and or a complete radiolucent line >2 mm in thickness with poorly defined margins. The incidence of radiolucent lines in UKA increases relative to the number of years of follow-up. Scott et al reported 55% incomplete radiolucent tibial component lines and 10% femoral component lines at 8- to 12-year follow-up without symptoms of loosening. Femoral components seemed to have fewer radiolucent lines; however, this may have been due to overlap of the metallic prosthesis in radiographs that were not fluoroscopically controlled to eliminate the obliquity of the technique. Mallory and Doblois reported that patients with radiographic evidence of loosening of a UKA had continuous symptoms of mild pain. However, in an average 5-year follow-up study of 33 UKAs, Klemme et al found that there was no relationship between nonspecific periprosthetic radiolucency and clinical knee scores or failures resulting in revision. Improved clinical results in medial UKA were associated with a central or slightly mediolateral mechanical axis. Weale et al reported an increase of 2° of varus limb alignment between eight months and five years postoperatively with no correlation between the postoperative tibiofemoral angle and the extent of recurrent varus. He concluded that minor polyethylene wear or tibial component subsidence accounted for these changes in the knee alignment.

Studies evaluating progression of disease in the opposite tibiofemoral or the patellofemoral compartment typically use Ahlbäck’s grading system. Ahlback described six stages of progression of osteoarthritis on radiographic evaluation of the joint. Grade I has slight joint space narrowing, Grade II has complete loss of joint space without bone loss, Grade III has loss of the joint space and slight bone attrition, Grade IV has moderate bone attrition, Grade V has severe bone attrition, and Grade VI has bone attrition and subluxation of the joint.

Marmor reported no significant increase in the opposite compartment. Kozinn and Scott reported failures due to progression in the opposite compartment; however, this may have been due to over correction of the knee. Berger et al reported minimal change in the opposite compartment with 12-year follow-up radiographs.

**The newer designs of UKA sacrifice less bone for the implant and are more like a resurfacing procedure.**

**Revision Surgery After UKA**

Initial studies stated that revision of UKA to a TKA was difficult because of the associated bone loss and the need for augmentation with either allograft or metallic wedges. The results of the surgery were not as good as those of primary TKA. Subsequently, Lai and Rand published their retrospective review of 48 patients undergoing revision of UKA at an average of 5.4 years from the index of surgery. All revisions were accomplished with a condylar type prosthesis. Fifty percent of the knees contained defects that could be filled with cement. The results were 81% good or excellent with a 13% surgical complication rate.

A retrospective matched pair analysis comparing 30 TKAs following HTO with 30 following UKA was reported by Gill et al. The authors found no difference in difficulty of exposure between the two groups; however, more bone defects required reconstruction in the UKA group. The overall results of TKA after UKA were not as good as the results of TKA after HTO. Levine et al reported a series of 31 successful conversions of failed TKAs with the use of cancellous grafts or simple metal augments to fill the defects. They were also able to preserve the posterior cruciate ligament as in a primary TKA. Chakrabarty et al reported on 73 revision UKAs converted to TKAs with the use of the presently available range of revision instrument systems. Minimal tibial bone was sacrificed and the average tibial polyethylene insert thickness was 11.5 mm. The newer designs of UKA sacrifice less bone for the implant and are more like a resurfacing procedure. Thus, if revision becomes necessary, the procedure can be completed with less need for bone augmentation.

**Conclusion**

After nearly 30 years of controversy, many recent articles have reported favorable results with UKA. The results suggest that the surgical procedure should be reconsidered. With the use of the minimally invasive technique, the morbidity of UKA has been reduced and the recovery has been shortened. The articles indicate that patient selection, radiographic evaluation, surgical technique, and prosthetic design all contribute to the final result. The long-term results along with the success of UKA revision to a primary TKA lend some credence to the idea that UKA may be considered as a pre-TKA for the younger-aged patients. In addition, the less invasive surgery may be more suitable for symptomatic patients whose medical conditions do not permit the standard total knee approach.

**References**


50. Weale A, Murray DW, Crawford R, et al. Does arthritis progress in the retained com-


