

# Unicompartmental Knee Arthroplasty: Past, Present, and Future

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## Abstract

Unicompartmental knee arthroplasty (UKA) has a more than 30-year history in the treatment of arthritis of one compartment of the tibiofemoral joint. Despite early negative reports, the procedure has evolved into a reliable and safe treatment. Successful outcomes with UKA require proper patient selection, meticulous surgical technique, and avoidance of deformity overcorrection. This procedure is indicated for patients with localized pain, preserved range of motion, and radiographically isolated tibiofemoral disease. UKA can provide more range of motion and improved patient satisfaction relative to total knee arthroplasty with comparable midterm longevity.

The typical clinical presentation of unicompartmental arthrosis is pain and tenderness in the region of the affected compartment, often with crepitance, osteophytes, angular deformity, and collateral ligament laxity due to cartilage loss. Nonoperative treatments (eg, activity modification, nonsteroidal anti-inflammatory drugs, chondroprotective agents, intra-articular injections, orthotic devices) can be effective in mild cases.<sup>1</sup> Surgical options for unicompartmental arthrosis include osteotomy, unicompartmental knee arthroplasty (UKA), and total knee arthroplasty (TKA). Although some early reports suggested

unpredictable results with UKA, improvements in implants, in instrumentation, and in the understanding of proper patient selection and surgical technique have led to markedly improved outcomes with this procedure.

## HISTORICAL BACKGROUND

The history of modern UKA prostheses can be traced to tibial hemiarthroplasty implants. The cobalt-chromium alloy MacIntosh prosthesis was introduced in 1964. The superior surface of this prosthesis had a smooth, concave shape, and the undersurface had a flat, serrated texture. Developed concurrently was the metal-resurfacing McKeever prosthesis with its T-shaped fin on the undersurface for added stabilization. Short- and intermediate-follow-up reports on both prostheses noted good results in 70% to 90% of patients.<sup>2-4</sup> More recently, Springer and colleagues<sup>5</sup> reported on the long-term results of 26 knees in patients younger than 60 treated with a McKeever prosthesis at a mean follow-up of 16.8 years (range, 12-29 years). Two patients died, and 1 was lost to follow-up. Of the remaining 23 knees, 13 were revised at a mean of 8 years after the index surgery. The remaining patients maintained a high degree of pain relief, functional performance, and satisfaction with the procedure.

The next chapter in the evolution of UKA came in the late 1960s and coincided with the early development of TKA. Implants such as the St. Georg Sled<sup>6</sup> (Waldemar Link, Hamburg, Germany), the Polycentric Knee (Protek, Berne, Switzerland),<sup>7</sup> and the Marmor<sup>8</sup> (Smith & Nephew, Memphis, TN) were developed. These were used in either a unicompartmental mode or a bicompartamental mode depending on the area of arthritic involvement. Early studies showed suboptimal results.<sup>9,10</sup> Laskin<sup>9</sup> reported that approximately one third of a series of 37 UKAs had poor clinical scores at follow-up, that nearly 1 in 5 required revision, and that one third of the knees had at least 2 mm of tibial component settling. In this series, the preexisting deformity was routinely overcorrected with insertion of the "thickest tibial implant that would permit gliding of the prosthetic joint surfaces." The technique of overcorrection of coronal deformity has since been recognized as a major risk factor for poor outcome after UKA. In addition, many knees with previous patellectomy, tibial component settling, or thin polyethylene inserts were included in these series.

## INDICATIONS FOR UKA

Patient selection is critical to long-term success after UKA. Kozinn and Scott<sup>11</sup> described the most commonly quoted

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selection criteria for UKA. According to these criteria, the ideal patient is at least 60 years old, weighs less than 180 pounds (82 kg), has a low level of activity, and has minimal pain at rest. The authors noted better results in the presence of a minimum range of motion (ROM) arc of 90°, with no more than a 5° flexion contracture, and a correctable maximal anatomical coronal deformity of 10° varus or 15° valgus.

Inflammatory diseases (eg, rheumatoid arthritis, crystalline arthropathy) are relative contraindications to this procedure based on the risk for contralateral or patellofemoral degeneration and synovitis. This situation was corroborated by 2002 Swedish Knee Arthroplasty Register<sup>12</sup> data revealing a significantly higher failure rate in UKAs performed for rheumatoid arthritis compared with osteoarthritis. Patient weight has a direct relationship to need for revision after UKA, according to a study by Heck and colleagues.<sup>13</sup> In their series of 294 knees, mean weight of patients who required revision was 90 kg compared with 67 kg in cases of nonrevised knees. In contrast, Pennington and colleagues<sup>14</sup> found 11-year survival of more than 90% in a series of patients with a mean weight of 90 kg.

UKA in the presence of chondromalacia in the opposite compartment can lead to good results, according to Corpe and Engh,<sup>15</sup> who achieved 89% excellent results at 32 months despite the presence of chondromalacia and even up to a 10% area of eburnated bone in the contralateral compartment. Others have also achieved good results with UKA in knees with patellofemoral chondromalacia.<sup>11,16,17</sup> In spite of these reports, most authors believe that substantial degenerative disease of the opposite tibiofemoral or the patellofemoral joint is a contraindication for UKA.

The role of the anterior cruciate ligament (ACL) in UKA has been an area of debate. White and colleagues<sup>18</sup> noted a specific pattern of arthrosis on the anteromedial tibial plateau in knees with an intact ACL. The varus deformity seen on the standing films disappeared with knee flexion because of the preservation of posteromedial tibial articular cartilage and femoral rollback onto this segment. As a result, the medial collateral ligament was maintained at the proper length, allowing for a correctable varus deformity. The authors hypothesized that absence of the ACL leads to a fixed deformity that can progress to degeneration of the posteromedial knee and the lateral compartment. Thus, an intact ACL is thought to prevent global joint degeneration and development of fixed varus deformity. Goodfellow and O'Connor<sup>19</sup> compared the results of the Oxford UKA with and without a functional ACL and found that the survival rate dropped from 95% to 81% in cases with a damaged or absent ACL. Suggs and colleagues<sup>20</sup> demonstrated increased tibial translation of approximately 1 cm at a wide range of knee flexion angles in the setting of ACL insufficiency both before and after UKA in a cadaveric model. This instability may increase polyethylene wear or implant loosening in some designs and account for the higher failure rates of UKA under these circumstances.

The appropriate minimum patient age for UKA is currently unknown. On the basis of traditional indications,

patients younger than 60 have not been considered for this procedure. Recently, with technical improvements, many surgeons have performed this procedure in a younger, more active patient population. Schai and colleagues<sup>21</sup> reported on UKA on 28 knees in middle-aged patients (mean age, 52 years). Ninety percent of knees were rated good or excellent at a mean follow-up of 40 months, and only 2 knees were revised. Engh and McAuley<sup>22</sup> performed 49 UKAs in patients between the ages of 40 and 60. When failure due to thin polyethylene components was excluded, the overall survival rate at 7 years was 86%. In a retrospective study by Pennington and colleagues,<sup>14</sup> 45 UKAs performed in patients between the ages of 35 and 60 were evaluated at a mean follow-up of 11 years. Three knees were revised. Of the remaining, 93% had an excellent Hospital for Special Surgery (HSS) score. Most patients participated in moderate sports activities, such as swimming, and had unlimited walking tolerance. Eleven-year survivorship was 92%. These reports support use of UKA as an alternative in young, active patients, though length of follow-up in most of the series is short compared with the life expectancy of most young patients.<sup>23</sup>

In spite of the predominance of medial procedures, UKA has also been used successfully in the lateral tibiofemoral joint. Early reports, by Insall and Walker<sup>10</sup> (1976), Laskin<sup>9</sup> (1978), and Insall and Aglietti<sup>24</sup> (1980), actually suggested better results with lateral UKA. Lateral procedures have made up approximately 5% to 15% of all UKAs in several series.<sup>13,25-29</sup> Marmor<sup>30</sup> reported excellent results in 80% (11/14) of lateral UKAs at a mean follow-up of 89 months. In another series, 16 of 18 lateral UKAs had good or excellent HSS scores at a minimum follow-up of 5 years.<sup>31</sup> Ashraf and colleagues<sup>32</sup> published results of 88 lateral UKAs using the St. Georg prosthesis with a mean follow-up of 9 years. The 10-year survival rate was 83%. Fifteen knees underwent revision surgery. Within this group, 9 had progression on the medial side, 6 had loosening, and 4 had a fracture of the femoral component. Excluding fractures of the femoral component, the authors demonstrated results comparable with those for medial UKA from the same institution by the same group of surgeons. Sah and Scott<sup>33</sup> reported on 49 lateral UKAs performed through a medial parapatellar approach. This approach was preferred because of its safety, familiarity, and easy intraoperative conversion to TKA. Surprisingly, 50% of patients thought to be candidates for lateral UKA were instead treated with TKA. At a mean 5-year follow-up, their results were comparable with those for medial UKA. The knees with posttraumatic arthritis tended to yield inferior results compared with the group with primary osteoarthritis.

## ALIGNMENT

In the early experience with UKA, the treated compartment was often filled with an excessively thick implant. Later, many authors noted better results with slight undercorrection, and this has been borne out in several long-term follow-up stud-

ies.<sup>14,25,34-36</sup> Not surprisingly, increased polyethylene wear and deformity recurrence have been found in cases of severe undercorrection and increased contralateral degeneration in the setting of overcorrection.<sup>35</sup> Modular, metal-backed tibial components are particularly helpful, as they allow adjustment of final implant thickness and modulation of the correction. Several techniques have been used for intraoperative avoidance of overcorrection. With an opening varus or valgus load in full extension, the treated compartment should open approximately 2 to 3 mm. Intraoperative radiographs are also helpful in direct measurement of the coronal alignment.

### SLOPE

The issue of tibial slope for UKA has important implications for the anteroposterior stability of the knee as well as the survival of UKA implants. Hernigou and Deschamps<sup>37</sup> studied 99 UKA procedures at a mean follow-up of 16 years. They found a linear relationship between posterior tibial implant slope and anterior tibial translation. Furthermore, implants with increased slope had a higher rate of loosening. In 5 knees, the ACL ruptured in spite of being normal at UKA surgery. The tibial slope in all these knees was 13° or more. There was an intriguing finding in the subgroup of 18 knees that had an absent ACL at time of procedure: Whereas 7 of

these knees had loosened and had a mean tibial slope of 11° (range, 9°-12°), the other 11 knees, which had not loosened, had a mean tibial slope of 0° (range, -6° to 4°). The findings of this study suggest that the optimal posterior slope for UKA tibial implants is less than 7°. Furthermore, in the setting of ACL insufficiency, the optimal slope is neutral or perpendicular to the mechanical axis of the tibia in the sagittal plane.

### DESIGN CONCEPTS

Overall design of the UKA has undergone relatively few changes over the past 30 years. The Table presents a summary of the results of a number of contemporary UKA series. Major modifications include use of cementless fixation, development of mobile-bearing designs, and use of modular tibial components. Rotational control features, such as fins or pegs, have been incorporated into femoral component designs to optimize fixation.

UKAs can be broadly categorized according to bone-cut preparation (resurfacing vs inset) and bearing surface (fixed-bearing vs mobile-bearing). The resurfacing technique focuses on minimal bone resection and placement of the implants on the subchondral bone. In contrast, inset implants require angular cutting guides similar to those used in TKA. The bearing surfaces are typically all polyethylene

**Table. Published Intermediate and Long-Term Results of Unicompartmental Knee Arthroplasty**

Authors	Year	Implant	Age (y) at Operation, mean (range)	Follow-Up (y), mean (range)	Knees at Study Inception (n)	Knees at Follow-Up (n)	10-Year Survivorship	Comments
Scott et al <sup>26</sup>	1991	Brigham (J&J)	71 (41-85)	10 (8-12)	100	64	85%	87% with no pain at follow-up
Heck et al <sup>13</sup>	1993	Compartmental I/II (Zimmer), Marmor (Richards)	68.2 (22-92)	6 (N/A-15)	294	250	91%	Patient weight, 90.4 kg (revisions), 67 kg (nonrevised cases)
Cartier et al <sup>28</sup>	1996	Marmor (Richards)	65 (28-82)	12 (10-18)	207	60	93%	
Ansari et al <sup>16</sup>	1997	St. Georg Sled (Link)	70 (46-93)	4 (1-17)	461	437	88%	92% good/excellent Bristol Knee Score
Murray et al <sup>17</sup>	1998	Oxford (Biomet)	70.7 (34.6-90.6)	7.6 (N/A-13.8)	143	109	97%	
Berger et al <sup>25</sup>	1999	Miller-Galante (Zimmer)	68 (51-84)	7.5 (6-10)	62	51	98%	HSS score increased from 55 (before surgery) to 92 (at follow-up); 98% good/excellent results
Squire et al <sup>27</sup>	1999	Marmor (Richards)	70.9 (51-94)	18 (15-22)	140	48	84% (22 years)	
Svard & Price <sup>50</sup>	2001	Oxford (Biomet)	69.6 (50.7-85.7)	12.5	124	94	95%	6 revisions (3 for bearing dislocation; 2, loosening; 1, infection)
Ashraf et al <sup>32</sup>	2002	St. Georg Sled (Link)	69	9.0 (2-21)	88	83	83%	All lateral procedures, 4 of 15 failures due to fracture of femoral component
Argenson et al <sup>34</sup>	2002	Miller-Galante (Zimmer)	66 (35-88)	5.5 (3-9.3)	171	160	94%	91% medial procedures; HSS score improved from 59 (range, 10-90) before surgery to 96 (range, 50-100) at latest follow-up
Pennington et al <sup>14</sup>	2003	Miller-Galante (Zimmer)	54 (35-60)	11 (5.6-13.8)	46	45	92% (11 years)	All patients younger than 60; mean weight, 90 kg; HSS score increased from 59 to 94 among nonrevised cases (42/45)
Naudie et al <sup>47</sup>	2004	Miller-Galante (Zimmer)	68 (39-87)	10 (3-14)	113	97	90%	All medial UKAs
Steele et al <sup>40</sup>	2006	St. Georg Sled (Link)	67 (36-85)	14.8 (10-29.4)	203	134	80% (25 years)	16 revisions, 2 for more than 1 indication (7 for disease progression; 3, wear; 4, tibial loosening; 2, fracture of femoral component; 2, infection)
Springer et al <sup>5</sup>	2006	McKeever Hemiarthroplasty (Howmedica)	45 (22-58)	16.8 (12-29)	26	23	13/23 revised during study follow-up period	Clinical scores available for 9 of 10 remaining implants: mean Knee Society Clinical score, 80 (range, 45-100), mean Knee Society Functional score, 97 (range, 80-100)

Abbreviations: N/A, not applicable; HSS, Hospital for Special Surgery; UKA, unicompartmental knee arthroplasty.



**Figure 1.** Repicci unicompartmental knee prosthesis with all-polyethylene tibial component (Biomet, Warsaw, Ind). Reproduced with permission.

or modular. The modular implants include fixed-bearing implants and mobile-bearing implants. In the fixed-bearing implants, the polyethylene insert is engaged into the locking mechanism of the tibial component; the mobile-bearing designs have a flat articular tibial implant surface, a round femoral component surface, and a conforming polyethylene insert that translates between the metal components. As a general rule, fixed-bearing UKA articulations have had the best results with a round-on-relatively flat bearing combination and without highly conforming surfaces. Conforming articulations have been more successful as mobile-bearing implants based on their ability to dissipate forces away from the fixation interface.<sup>38</sup>

### Resurfacing

The resurfacing technique refers to use of hand and motorized instruments in débridement and preparation of bone surfaces. This category includes the original Marmor, the St. Georg, and the Repicci (Biomet, Warsaw, IN) designs. Resection of the optimal amount of bone for stable fixation and accurate alignment can be challenging because of limited use of guides. The St. Georg prosthesis, which has been in clinical use since 1969,<sup>39</sup> consists of a biconcave metal femoral component and a flat, cemented, all-polyethylene tibial component. Over a minimum of 10 years, Steele and colleagues<sup>40</sup> followed a group of 203 knees treated with the St. Georg UKA. Of these 203 knees, 99 remained in situ at 15 years, 21 at 20 years, 4 at 25 years, and 69 at time of patient death. Sixteen revisions were undertaken at a mean of 13 years from the index operation. Kaplan-Meier survivorship was 85.9% at 20 years. The most common source of failure was progression of arthritis, followed by wear, tibial loosening, fracture of the femoral component, and infection. The Marmor UKA was first performed in the early 1970s.<sup>8</sup> The implant was composed of a stainless-steel femoral component and an all-polyethylene tibial component. Marmor<sup>41</sup> reported minimum 10-year data on 60 knees with 70% survivorship and 63% good/excellent results. He attributed the majority of failures to selection of poor candidates (eg, obese patients, patients



**Figure 2.** Miller-Galante unicompartmental knee prosthesis (Zimmer, Warsaw, Ind) with modular polyethylene tibial insert. Reproduced with permission.

with significant deformities). The major cause of failure was loosening of the 6-mm polyethylene tibial components, which actually measured 4 mm at their thinnest point. Squire and colleagues<sup>27</sup> reported the longest term follow-up UKA study to date, with 140 UKAs at a minimum follow-up of 15 years using the Marmor implant. The 22-year survivorship with revision as the endpoint was 84%.

The Repicci UKA prosthesis consists of a cobalt-chrome femoral component and an all-polyethylene tibial component (Figure 1). The femoral component contains a single fixation peg attached to a sagittally oriented fin. Preparation of bony surfaces depends on maintenance of subchondral bone for support and hand preparation of bony surfaces with burrs. According to Romanowski and Repicci,<sup>42</sup> 60% of 136 consecutive medial UKAs had excellent results, 26% had good results, and 14% had fair or poor results, with an overall 8-year survivorship of 93%.

### Inset

Inset UKA designs require a femoral preparation technique similar to that used in TKA. A broad surface of cancellous bone is created to exactly match the inner dimensions of the components and to form a high contact area between implant, cement, and bone.

The Porous Coated Anatomic knee (PCA; Stryker, Mahwah, NJ), an inset prosthesis, had suboptimal clinical results. The geometry of the polyethylene insert of the PCA resulted in constraint of range of motion (ROM) and a small contact area. The femoral component was found to ride up the central slope of the tibial component and promote wear in this region.<sup>43</sup> The polyethylene of the PCA was heat-treated to decrease friction and to increase wear resistance. Unfortunately, the resulting material showed a high degree of pitting and delamination.<sup>43</sup> The failure rate in one series was 20% at 26 months.<sup>44</sup> Similar failure rates have been noted in several other studies of the PCA implant.<sup>45,46</sup>

Another inset prosthesis, the Miller-Galante (Zimmer, Warsaw, Ind), has had more promising results (Figure 2). The relatively flat tibial articular surface allows for uncon-



**Figure 3.** Oxford unicompartmental knee prosthesis (Biomet, Warsaw, Ind), a meniscal bearing prosthesis with a flat, polished tibial surface and a highly conforming articulation between the femoral component and the polyethylene insert. Reproduced with permission.

strained motion. Argenson and colleagues<sup>34</sup> reported on 147 Miller-Galante UKA procedures at a mean follow-up of 66 months (range, 36-112 months). Three knees required revision because of degeneration in the unresurfaced compartments (2 patellofemoral, 1 lateral), and 2 knees required revision of the insert for polyethylene wear. Ten-year Kaplan-Meier survival was 94%. The longest term results available on the Miller-Galante implant are those published by Naudie and colleagues.<sup>47</sup> In their series, 113 medial UKAs were followed for a mean of 10 years. Of the 97 knees available, 11 had been revised with a 10-year survival of 90%. These findings show that inset prostheses can achieve excellent intermediate-term results in the setting of appropriate patient selection, use of relatively thick polyethylene inserts, and cemented fixation of implants. The poor results demonstrated with the PCA inset prosthesis reflect use of cementless fixation, thin polyethylene inserts with poor material properties, and a constrained surface design that led to increased shear stress at the implant–bone interface.

### Mobile-Bearing

The Oxford mobile-bearing prosthesis was introduced by Goodfellow and O'Connor<sup>48</sup> in 1978 (Figure 3). Its highly congruent femoral component–polyethylene articulation is combined with a flat, polyethylene-bearing undersurface that rests on a correspondingly flat metal tibial tray. The polyethylene bearing (meniscal bearing) is maintained in reduced position by the congruency and by soft-tissue tension. The potential advantage of this design is a femoral–polyethylene interface with a large contact area (nearly 6 cm<sup>2</sup>). The flat-on-flat tibial–polyethylene articulation has further contributed to extremely low wear measurements, on the order of 0.01 to 0.03 mm/y.<sup>49</sup> The Oxford medial-compartment UKA as used by its designers has achieved an astounding 98% 10-year survivorship. Such high success has also been achieved by other groups of

surgeons, with a 10-year survivorship of 95% in a series of 125 UKAs.<sup>50</sup> Tibial polyethylene dislocation is a unique complication that can occur with mobile-bearing implant designs, emphasizing the importance of extension and flexion balancing. According to Swedish Knee Arthroplasty Register<sup>12</sup> data, the Oxford UKA, when evaluated by a large number of surgeons across Sweden, had slightly lower revision-free survival than fixed-bearing implants, such as the St. Georg. Furthermore, results improved dramatically in centers where more than 23 procedures were performed annually. These findings may reflect the technical difficulty of achieving optimal soft-tissue balance with mobile-bearing designs.

### COMPLICATIONS

In early reports, UKA complications were often related to factors that in many cases have since become better understood. There have been many improvements in patient selection, implant design, and surgical technique. The most common failure modes are contralateral tibiofemoral or patellofemoral arthritis, implant loosening with or without polyethylene wear, and mechanical failure.

Scott and colleagues<sup>26</sup> reported long-term results for 100 UKAs at a minimum 8-year follow-up. Thirteen of the knees had been revised: 9 for loosening, 3 for progression of disease, and 1 for instability. Squire and colleagues<sup>27</sup> performed 14 revisions in a series of 140 UKAs at a minimum 15-year follow-up. Indications for revision were tibial loosening (6 knees), disease progression (7), and knee pain (1). Berger and colleagues<sup>25</sup> reported 2 reoperations from a series of 62 UKAs at a mean of 7.5 years. One was for retained cement, the other for contralateral tibiofemoral degeneration.

**“More recently, Chakrabarty and colleagues<sup>54</sup> had relatively little difficulty in a series of 73 UKA-to-TKA revisions.”**

Hernigou and Deschamps<sup>51</sup> addressed the issue of patellofemoral degeneration by dividing such complications into cases of impingement and cases of patellofemoral arthritis. Approximately one fourth of their series of 99 knees developed patellofemoral arthritis, and another fourth had patellar impingement at a mean radiographic follow-up of 14 years. These 2 conditions were mutually exclusive in their series.

### UKA Revision

The most common treatment for failed UKA is revision to TKA. As technical and implant-related factors have improved, the challenges of such revisions have gradually decreased. For example, in a 1991 series of 21 knees, 16 had a major osseous defect.<sup>52</sup> The authors concluded

that revision of a UKA to a TKA provides no advantages regarding technical ease or bone loss compared with a standard revision TKA. Of a series of 29 knees, reported by Levine and colleagues,<sup>53</sup> 7 required cancellous bone grafting, 6 required metal wedges, and none required structural grafting. More recently, Chakrabarty and colleagues<sup>54</sup> had relatively little difficulty in a series of 73 UKA-to-TKA revisions. Forty-two percent of the knees had no bony defect, an additional 36% had only a small defect, and 22% had a major defect usually addressed with prosthetic augments. Furthermore, use of stemmed total knee components is recommended in conversions to TKA.

### MINIMALLY INVASIVE UKA

Minimally invasive surgery refers to surgical procedures that involve small skin incisions and altered surgical exposures used in the hope of decreasing soft-tissue trauma and dissection. This concept has been applied to UKA in an attempt to expedite recovery and return to activity. Repicci and Eberle,<sup>55</sup> who performed UKA through a 3-inch (7.5-cm) incision, indicated that 80% of UKA surgeries can be performed on an outpatient basis. With use of this technique, estimated mean cost of UKA was \$7000 compared with \$16,000 for UKA with a standard knee incision and patellar eversion.

Price and colleagues<sup>56</sup> prospectively compared UKA performed through a short incision without patellar eversion with UKA performed through a standard incision with patellar eversion and with TKA performed through a standard incision. Recovery was 2 times as rapid in the minimally invasive group versus the standard UKA group and 3 times as rapid versus the standard TKA group. Implant position on postoperative radiographs was not compromised with the minimally invasive procedure. Fisher and colleagues<sup>57</sup> retrospectively compared 88 minimally invasive UKAs with 64 UKAs performed through a standard arthrotomy and compared the final limb alignment and the position of the implants in the coronal plane. They found that the tibial components in the minimally invasive UKAs were placed in significantly more varus than those in the standard UKAs ( $5.4^\circ$  vs  $4.1^\circ$  varus). Furthermore, limb alignment was also different between minimally invasive and standard UKAs ( $3.5^\circ$  vs  $4.3^\circ$  valgus; ideal goal,  $5^\circ$  valgus). The coronal alignment demonstrated a higher standard deviation in the minimally invasive group, indicating less reproducible implant placement. The implications of this finding for the long-term results of the procedure with contemporary implants are unknown.

The potential benefits of minimally invasive surgery and early hospital discharge must be carefully weighed against the risks for soft-tissue trauma from forceful retraction, inadequate visualization and exposure, and increased risk for unrecognized complications, such as thrombosis in the outpatient setting.

### CONCLUSIONS

UKA is a proven surgical option in the treatment of isolated arthrosis of one compartment of the tibiofemoral joint. Traditional indications have consistently led to excellent long-

term results in the absence of other issues, such as material deficits of the implants and overcorrection of deformity.

With proper patient selection, unicompartmental procedures may have some advantage over TKAs, specifically in the areas of ROM and subjective patient preference.<sup>58</sup> Other advantages of UKAs over TKAs are decreased cost, shorter hospital stay, smaller incisions, and improved rehabilitation.<sup>59</sup>

Successful outcomes can be achieved with any of the various designs as long as the concepts of patient selection, unconstrained implant geometry, cemented fixation, appropriately thick polyethylene, and proper surgical technique are followed. In cases of excessive deformity, decreased ROM, or bicompartmental tibiofemoral arthritis, TKA is preferable. The benefits of minimally invasive procedures must be weighed against the challenges of decreased visualization, potentially increased soft-tissue trauma, and risk for implant malposition.

### AUTHORS' DISCLOSURE STATEMENT

Dr. Jamali wishes to note that he was awarded a basic science research grant from Biomet for procedures not related to joint replacement and, specifically, not related to unicompartmental knee arthroplasty.

Dr. Scott wishes to note that he has received royalties from DePuy, Inc, for certain total knee prostheses but none for unicompartmental prostheses.

Dr. Rubash wishes to note that he is a designing surgeon for Zimmer, Inc. However, this relationship does not pertain to UKA. He also wishes to note that the Department of Orthopaedics at Massachusetts General Hospital receives research funding from Zimmer, Biomet, and Smith & Nephew.

Dr. Freiberg wishes to note that Massachusetts General Hospital receives royalties from Biomet and Zimmer. He also wishes to note that he has previously served (but is not currently serving) as a consultant to Zimmer and that he receives royalties from Zimmer.

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