

Unicompartmental knee arthroplasty MANUAL

Bruce Gomberg, MD

Matteo Marullo, MD

Editors and Co-Chairs, EKA Small Implant Group

Joan Leal-Blanquet MD PhD

Josina Maiti Muenchgesang,

Daniel Guenther, MD PhD

Michael Clarius MD PhD

Michele Vasso, MD

Marco Bargagliotti MD, Fabrizio Di Feo MD

Johannes Beckmann, MD PhD

Andrea Parente MD

Paweł Skowronek MD PhD, Agnieszka Bartyzel MD, Łukasz Dutka MD, Michał Skowronek MD

Theofylaktos Kyriakidis MD, MSc, PhD, Ioannis Samaras MD

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Chapter 1: General health - Bruce Gomberg

To improve patient outcomes, it is imperative to thoroughly assess the patient's general preoperative health and optimise any modifiable risk factors prior to surgery. The preoperative health of the surgical patient has a significant influence on the peri-operative course, ultimate outcome and cost of treatment. It is well-documented in the arthroplasty literature that increasing patient comorbidities correlates with a decline in outcomes, an increase in hospital readmissions, and an increased cost of care. 1,2

The importance of optimisation of the patient's general health is particular to the unicompartmental knee arthroplasty patient, since the window of hands-on healthcare is narrow, often being performed as completely outpatient procedures and requiring less than 23 hours of in-hospital care. A readmission or delay of discharge (now known as a "failure to launch") represents a notably unique and substantial spike in hospital costs and a decline in patient outcomes. Being proactive prior to surgery has a large impact on minimising these downstream effects.

While there is a paucity of literature on the general pre-operative health of the unicompartmental knee arthroplasty patient, there is significant research focused on comorbidities in the total knee and total hip arthroplasty patients, and these conclusions easily transfer to the unicompartmental knee arthroplasty patient. Traditionally, there has been a bimodal population of unicompartmental knee arthroplasty patients: those healthier and younger than total knee arthroplasty patients, having fewer underlying medical issues, and those older with more medical comorbidities. However, as the indications for unicompartmental knees broaden and the performance of the surgery increases, more unicompartmental knee arthroplasty patients have at least some underlying medical comorbidities.

UKA patients should have their pre-operative medical issues scrutinised and optimized as any arthroplasty patient would since medical comorbidities have the same effect regardless of the operation, and UKA patients can be expected to follow roughly the same demographics as TKA patients. Recent publications showed that nearly 84% of arthroplasty patients had at least 1 preoperative comorbidity with an average of nearly 2 pre-operative comorbidities, commonly hypertension, diabetes, obesity, and anaemia.[1,2] Hustedt et al. demonstrated that the risk of major postoperative complications increased with CHF, valvular heart disease and

COPD (and resultant thromboembolic events associated with COPD). [4] Patients with diabetes, even undiagnosed, have poorer outcomes and cost more per episode of care. [5]

Outpatient procedures like UKA are defined by patients' ability to quickly recover from surgery and be discharged home with minimal need for inpatient care. This process of rapid recovery is enhanced by carefully stratifying patients by preoperative medical comorbidities. That is, most same-day discharge programs have exclusion criteria concerning underlying comorbidities that focus on general health and include BMI, cardiopulmonary status, obstructive sleep apnea, age, glycemic control, and history of urinary retention. Increasingly, it is evident that pre-operative mental health (depression, anxiety and resilience) may play an important part in patient outcomes. [6] These all should be appropriately optimised and managed in the pre-operative period.

The ideal unicompartmental knee arthroplasty patient presents on the day of surgery with these general health modifiable risk factors optimised:

- Cardiopulmonary status (cleared by the cardiology and pulmonology teams if necessary)
- Obstructive sleep apnea (bring their CPAP machine if used)
- HbA1c (target less than 7%)
- Urinary retention
- Depression and anxiety
- BMI (ideally below 35 kg/m²)
- Smoking cessation achieved at least 6 weeks prior to surgery
- No preoperative narcotic usage

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Chapter 2: Localization of Pain as an indication for Unicompartmental Knee Arthroplasty - Joan Leal-Blanquet

Although it does not appear on the list of indications and contraindications (3), one sign that generates controversy is the location of the patient's pain. The best situation is that pain located only in the compartment of the knee to be replaced (4). In 2008, Bert established the surgical criterion of pain localized with one finger to the affected compartment as a surgical indication, explaining that generalized pain in the knee should be considered a favorable factor for non-implantation of a Unicompartmental arthroplasty(10). In 2010, a survey of 200 orthopedic surgeons in the United Kingdom found that a third of those surveyed agreed to consider anterior knee pain as a contraindication for unicompartmental prosthesis (16). However, evidence now exists that the location of pain in more than one compartment is not a contraindication for partial knee arthroplasty and that anterior knee pain correlates very poorly with osteoarthritis in this anterior compartment (7, 8, 9, 11, 12). A knee pain map, as described by Thompson et al.(18), may help define specific patterns of patients for whom a given treatment would be effective.

At present, preoperative pain location does not always correlate with the distribution of knee osteoarthritis or with the results obtained in patients undergoing unicompartmental arthroplasty and is an unreliable indicator of surgical success in UKA (17).

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Chapter 3: Imaging - Josina Maiti Muenchgesang¹, Daniel Guenther¹

¹Department of Orthopaedic Surgery, Trauma Surgery, and Sports Medicine, Cologne-Merheim Medical Center, Witten/Herdecke University

The aim of this chapter is to provide guidelines for preoperative, postoperative, and follow-up imaging in unicondylar knee arthroplasty (UKA). Imaging techniques, measurement techniques, and outcome parameters will be described.

Preoperative imaging:

Preoperative imaging is highly relevant to ensure proper indication and planning of UKA. In correlation with the clinical examination, it helps to identify the most appropriate UKA patients, differentiating them from those better suited for a total knee arthroplasty (TKA) or osteotomy (1).

The following imaging modalities (figure 1) in the preoperative setting are recommended:

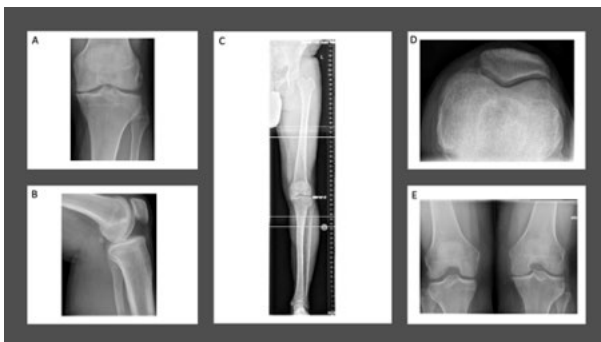


Fig. 1: Prior to Unicondylar Knee Arthroplasty (UKA), it is recommended to obtain at least the following imaging modalities: Plain radiographs in the antero-posterior (A), lateral (B), and axial (D) view, a weight-bearing long-leg standing radiograph (C), and a Rosenberg view (E).

Plain radiographs (antero-posterior (AP) view, lateral view, axial view):

Plain radiographs are mandatory to determine whether the osteoarthritis (OA) is limited to a single compartment or if multiple compartments are affected (2, 3). Furthermore, prosthesis size and resection course can be planned (2). For calibration purposes, it is

recommended to position a standardized, radiopaque ball centrally at the level of the compartment of interest (4)

A decision aid was established for medial meniscal-bearing UKA in differentiation from TKA, which (after exclusion of patients with decision to TKA due to personal reasons) has a sensitivity of 93% and a specificity of 96% (5). It claims the following radiographs to be mandatory: AP weight-bearing, true lateral, valgus-stress, and skyline view (5). Additional information can be acquired by varus-imaging or Rosenberg posteroanterior imaging in the absence of evidence of “bone-on-bone” sign in the standard AP view (5).

In the strict lateral view (with superimposition of the condyles and slight knee flexion), the functional capacity of the anterior cruciate ligament (ACL) can be assessed. In chronic ACL-insufficiency, erosion of the posterior tibial plateau and anterior tibial subluxation may be detected (5, 6).

An axial view should be included to assess for possible patellofemoral OA or subluxation (3, 7). In this regard, we recommend the Merchant skyline view in 30° knee flexion (5).

The presence of patellofemoral OA may not affect the success or revision rate of UKA, so the indication for UKA could be extended (6, 7, 8). According to the decision aid mentioned above, only loss of bone stock of the lateral patella facet, grooving, and subluxation should be evaluated as contraindications for medial meniscal-bearing UKA (5). Publications describing the relationship between lateral UKA and patellofemoral OA are rare. A recent study suggests not to consider asymptomatic, mild to moderate patellofemoral OA (defined as OA less than grade 4 due to Kellgren and Lawrence, either of the medial or lateral facet) or patellofemoral malalignment as a contraindication for lateral UKA (9). The authors theorize that lateral UKA improves patellofemoral alignment and therefore load distribution (9) (for further information, see Chapter 8).

Weight-bearing long-leg standing radiographs and stress images:

A weight-bearing, long-leg standing radiograph is necessary to determine underlying coronal malalignment and ensure proper UKA planning. The coronal alignment of the lower leg can influence the preoperative decision and whether a UKA or an osteotomy is indicated (2, 10). It must be determined if an extra- or intraarticular deformity is the cause of malalignment. A proper preoperative plan, including determination of joint line obliquity

(JLO), anatomical femorotibial angle (aFTA), anatomical and mechanical medial proximal tibial angle (aMPTA/mMPTA), lateral distal femoral angle (aLDFA/mLDFFA) and lateral distal tibial angle (aLDTA/mLDTA), is necessary (10). The level of malalignment, either femoral, or tibial, or both, must be determined (10). Joint line narrowing due to OA can be corrected by means of UKA, whereas a femoral or tibial malalignment cannot (2). For further decision-making information, please see chapter on alignment. Joint line narrowing can be due to the progression of OA or due to ligamentous insufficiency. If in doubt, stress radiographs of both knees can help to evaluate ligamentous knee stability. Valgus stress images in AP projection with 20° flexion provide information about 1) preserved cartilage in the lateral compartment, and 2) the functionality of the medial collateral ligament (MCL) with correctable, possibly underlying intraarticular deformity (5, 11). The same is true for varus stress images, the lateral collateral ligament, and the medial compartment. During valgus/varus radiographs, the knee is padded with a cushion in 20° flexion to relax the posterior capsule-tendinous structures, and a defined force of 130-150 Newtons is applied (4).

The value of the valgus/varus stress radiographs is currently being critically discussed in favor of the Rosenberg view (4, 6). The Rosenberg radiograph can save both human and material resources with comparable information value (4). A preserved cartilage in the opposite compartment is characterized by at least 5 millimeters of cartilage thickness and parallel joint lines in both the varus/valgus and Rosenberg radiographs. (6). The so-called "wedge sign" in the sense of converging joint lines is a sign of cartilage lesions, ligamentous instabilities, or the above-mentioned alignment disorders and might reflect a potential contraindication for UKA (6).

Cross-sectional imaging

Until recently, magnetic resonance imaging (MRI) is recommended in the absence of a previous diagnostic arthroscopy in order to assess ligamentous structures and the degree of chondromalacia present (2). Alternatively, a diagnostic arthroscopy can be performed within a single-staged procedure, and implantation of a UKA can be performed according to the findings (1). However, it should be noted that MR morphology tends to overestimate chondromalacia and ligamentous lesion (12, 13), and past recommendations perceiving an insufficient ACL as a contraindication are being challenged (5) (for further information see chapter 9).

To date, computer tomography (CT) imaging is not standard. However, three-dimensional (3D) CT imaging and 3D-planning are required for patient specific implants and/or robotic surgery showing promising results in terms of patient outcomes (14).

Postoperative Imaging:

Postoperative imaging is required for proper quality control and to visualize the operative objectives. It is used to determine periprosthetic fractures, malalignment in coronal, sagittal, and axial planes, implant sizing, signs of patellofemoral notching or degenerative changes in the opposite and patellofemoral compartments. The authors recommend the following imaging modalities (figure 2) in the postoperative setting:

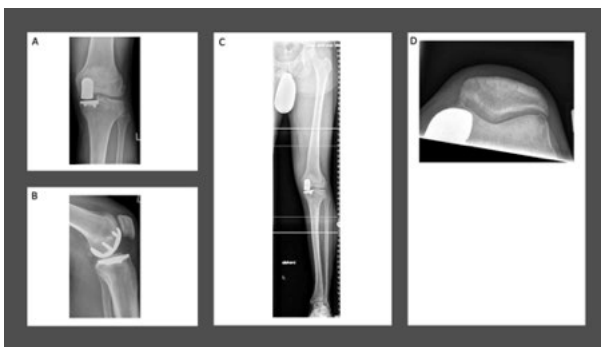


Fig. 2: In the postoperative setting post Unicondylar Knee Arthroplasty (UKA) it is recommended to obtain at least the following imaging modalities: Plain radiographs in the antero-posterior (A), lateral (B), and axial (D) view, and a weight-bearing long-leg standing radiograph (C).

Plain radiographs (AP view, lateral view):

Postoperative radiographic weight-bearing imaging in the AP and lateral views is considered mandatory to demonstrate the position of the UKA and exclude complications such as fractures (3). Sizing can be evaluated as follows: In the AP view, the distance between medial/lateral tibial cortex and the edge of the tibial implant is measured (14). In the lateral view, distances are calculated between anterior/posterior cortex and femoral/tibial implant. The posterior femoral offset, being the distance between the axis of the posterior diaphyseal cortex and posterior part of the condyle, should be evaluated (14). Cut-off values for over- and undersizing are set anteriorly, posteriorly, and medially at +/- 3 millimeters (14, 15).

Using this imaging, the evaluation of the implant axis is also possible. In the AP view, the tibial component should be implanted perpendicular to the tibial axis. In the lateral image,

the physiological slope should optimally be $<7^\circ$ (1, 16). The anterior surface of the femoral component should be oriented perpendicular to the femoral axis and display congruency in the patellofemoral alignment (17)

The axial patellofemoral image (Merchant view) can provide useful information regarding alignment, OA, and possible patellar impingement (16, 17).

A weight-bearing, long-leg standing radiograph is recommended to determine the postoperative leg axis and alignment (17). The mechanical axis should show a slight undercorrection to spare the native compartment and prevent polyethylene-wear through overstuffing (17).

Follow-up-Imaging:

Radiographs in the AP, lateral, and axial view are recommended 6 weeks postoperatively, then every 1-2 years up to 10 years postoperatively. Special interest should be paid to signs of loosening (defined by Berger et al. as more than two millimeters of subsidence or a new change of position in relation to the surrounding bone of more than three degree), migration, radiolucencies (17), or joint effusion. Degenerative changes in the opposite and the patellofemoral compartment and patellofemoral impingement must be staged, since they may become an indication for revision to TKA (17).

Take home messages:

- In the preoperative setting it is recommended to obtain at least the following imaging modalities: Plain radiographs in the antero-posterior, lateral, and axial view, a weight-bearing long-leg standing radiograph, and a Rosenberg view.
- In the postoperative setting it is recommended to obtain at least the following imaging modalities: Plain radiographs in the antero-posterior, lateral, and axial view, and a weight-bearing long-leg standing radiograph.
- Magnetic resonance imaging (MRI) is recommended in the absence of a previous diagnostic arthroscopy to assess ligamentous structures and the degree of chondromalacia present.
- Three-dimensional (3D) CT imaging and 3D-planning are required for patient specific implants and/or robotic surgery showing promising results in terms of patient outcomes.

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Chapter 4: Patient Age and UKA - Michael Clarius

Based on the current evidence, age is no longer considered a contraindication for unicompartmental knee arthroplasty in patients with the classic indication of anteromedial osteoarthritis of the knee (1). Kennedy et al. showed that the recommended indication of bone-on-bone arthritis should be used and is appropriate in all age groups (2).

Old age has been proposed as a relative UKA contraindication for a while (3).

However, the literature has shown that patients who underwent UKA compared to TKA showed less blood loss, decreased infection rates, shorter lengths of stay, reduced complication rates, faster recovery, shorter rehabilitation time, lower morbidity rates in terms of thromboembolic events and major cardiac events, as well as a lower mortality rates (4-6). Therefore, elderly patients seem to be the ideal candidates when they meet indication criteria (7) and should benefit in particular from this procedure. Ghomrawi et al. (8) also showed that UKA is a cost-effective solution compared to TKA in patients over 65.

Traditionally, Kozinn and Scott (9) suggested patients under 60 were not even suitable for a UKA. However, their recommendations were not evidence-based. In contrast, studies have shown that UKA is an attractive option with good and excellent clinical outcomes, a survival rate of more than 90% after 10 years and very high patient satisfaction in patients under 60 (10-16). With this supporting published data, younger age of less than 60 can no longer be regarded as a contraindication to UKA(17-19). However Parratte et al. (20) reported a series of 31 patients aged under 50 with 35 operated knees having a 12-year survival of 80% of fixed bearing UKA. Revisions were mostly due to wear indicating that, in this patient group, high activity and high patient demands lead to increased wear with fixed bearing UKA. However, he also reported encouraging clinical results in the unrevised patients.

Relative youth compared to the average age for joint replacement, is a recognized risk factor for implant survival both in UKA and TKA (21). In general, younger age is associated with a higher risk of revision (22). However, if a patient is likely to outlive a knee prosthesis, UKA is preferred, given the ease of a revision compared with TKA. In conclusion, UKA is an attractive option at all ages when patients meet the indication criteria.

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Chapter 5: Influence of BMI on unicompartmental knee replacement -
Michele Vasso¹, Katia Corona², Matteo Marullo³, Simone Cerciello⁴, Germano
Guerra²

¹ Karol Wojtyla Hospital, Unit of Knee Surgery and Sport Traumatology - Rome (Italy)

² Department of Medicine and Health Sciences “Vincenzo Tiberio” - University of
Molise, Campobasso (Italy)

³ IRCCS Ospedale Galeazzi, Department of Joint Replacement - Milan (Italy)

⁴ Casa di Cura Villa Betania - Rome (Italy)

The incidence and prevalence of obesity in the Western World is continually increasing [1]. Obesity is a state of excessive fat accumulation and is defined as a body mass index (BMI) of 30 kg/m² or greater [2]. It is well recognized that obesity accelerates the rate of osteoarthritis especially in the knee [3,4]. Some studies have shown that obesity is associated with increased revision rates and complications following UKA [5,6,7,8], while others have shown no effect on any clinical or functional outcome after UKA [9,10,11]. This resulted in specific BMI cut-offs when determining patient eligibility for arthroplasty [12,13].

Agarwal et al [14] performed a meta-analysis showing that obesity did not result in poorer post-operative outcomes following UKA. Additionally, subgroup analyses showed no statistically significant difference between patient cohorts with and without obesity in overall complication rates, infection rates, and revision surgeries. When further analyzing complications, no differences were identified in minor and major complications, such as venous thromboembolism, and no differences were identified in revision for infection or aseptic loosening. Notably, 18 of the 30 studies found that BMI had no effect on outcomes following UKA, however 12 studies determined that obesity in UKA patients was associated with poorer outcomes. The Authors concluded that obesity should not be considered an absolute contraindication for UKA and future studies including long-term follow-up RCTs and registry-level analyses should examine other factors associated with obesity, stratifying obesity to better delineate any potential differences in postoperative outcomes. Musbahi et al [15] in another meta-analysis including 9 studies and 4621 UKAs found no significant difference in outcomes and revision rates after UKA between obese (BMI > 30) and severely-obese (BMI > 35) patients when compared to non-obese patients. However, for patients with BMI above both 30 and 35 there was an increase, though not statistically significant, in the mean revision rate

at 10 years. Others conclude that obesity should not be considered an absolute contraindication to UKA and advocated further studies to explore the relationship between patient activity levels, surgeon's operative data, and implant design on UKA.

Giori et al [16] found that the risk of complications for obese patients with a BMI over 30 was lower than that in the super-obese patients (BMI over 40). Adhikary et al [1] reported that a BMI greater than 45 was associated with an increased risk of complications. Other authors found lower clinical and functional score and poorer implant survival rates at follow-up greater than ten years in patients with obesity [17,18,19]. Still other studies with long-term follow-up reported no difference in patients with or without obesity [9,10,21].

Agarwal et al [14] suggested that mobile-bearing UKA, which dispersed load more evenly, and robotic UKA, which may improve component positioning, could provide better outcomes and lower revision rates after UKA in obese patients. Musbahi et al [16] found that, in obese patients, revision rates of fixed bearing UKA was higher than that of mobile bearing, but the difference was not statistically significant. It was postulated that, since the failure rate in obese patients may be lower after UKA than TKA, it may be advantageous for obese patients to undergo a UKA rather than a TKA. [15]

Recently, Vasso et al [22] performed a meta-analysis to definitively collect and synthesize all the above-mentioned results. Authors found that the risk of conversion to TKA after UKA was higher for the obese and the severely obese group compared to the non-obese group, especially at 10 years of follow-up. Additionally, there were no differences in post-operative clinical scores and in most of functional scores, while the post-operative KSS functional score was lowest in the severely obese patient group. Obesity was not associated with a higher risk of infection after UKA and UKA resulted effective in relieving pain regardless of the degree of obesity.

In conclusion, obesity should not be considered an absolute contraindication to UKA, but expect higher revision rates and lower implant survival in long-term follow-up. Obesity will likely not influence clinical (including pain) and most functional outcomes after UKA, whereas KSS function score could be significantly lower only for the severely obese patients. Surgeons should continue to be appropriately cautious in obese patients, who should be warned that there might be an increased risk of revision especially if the state of obesity is maintained

over time. Obese patients should be educated regarding healthy lifestyle and motivated to lose weight before (and after) UKA.

Take-home messages

- Obesity (BMI 30 to $< 35 \text{ kg/m}^2$) should not be considered an absolute contraindication to UKA
- Obesity and severe obesity (BMI $> 35 \text{ kg/m}^2$) may be associated with significantly higher revision and lower implant survival rates, especially when obesity is not corrected over time
- Obesity could not influence clinical (including pain) and most of functional outcomes after UKA, whereas KSS function could be significantly lower only for the severely obese patients
- Unlike TKA, obesity has not found to be associated with a higher risk of postoperative UKA infection

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Chapter 6: Alignment in medial unicompartmental knee prostheses - Marco Bargagliotti MD, Fabrizio Di Feo MD

The concept of 'alignment' refers to both the orientation of the components with respect to the diaphyseal axis of the femur and tibia and the degree of intra-operative correction of the deformity in the lower limb. Surgical success, outcomes at follow-up and patient satisfaction depend on proper alignment. [1]

Over recent years, an improved understanding of the anatomy of the knee and its complex articular function [2, 3, 4] have led to a progressive evolution in the surgical technique of medial unicompartmental knee arthroplasty (UKA) as well, shifting from the 'traditional philosophy' of mechanical alignment (MA) of components – which involves bone cuts performed perpendicularly to the mechanical axis of the femur and tibia [5] - to a more modern concept of kinematic alignment (KA), according to the "Cartier angle technique", [6] a surgical technique which consists of cutting the tibial bone perpendicularly to the meta-epiphyseal axis of the bone, while cutting the distal femoral in parallel and symmetrically to the latter. [1, 7]

In contrast to MA, kinematic alignment allows for an anatomical orientation of the prostheses, guaranteeing a perfect congruence during joint flexion-extension, correct ligamentous balance and uniform load distribution. [8] As reported in the literature, the main reasons for the success of KA are excellent clinical and functional results and a reduced rate of implant failure at medium and long-term follow-up. [9]

The term "alignment" conveys the degree of surgical correction of the axis of the loaded lower limb, having its foundation in the "constitutional varus", introduced by Bellemans et al. [10]. It is now universally recognized that, in approximately 70% of normally- aligned knees, the load bearing axis crosses the medial compartment and not the anatomic centre of the joint. Therefore, during a medial unicompartmental prosthesis surgery, one aims to correct any extreme initial varus deformity of the limb while still respecting a certain residual degree in order to obtain a correct load distribution avoid overcorrection, a frequent cause of failure. [11]

Lower limb alignment is the angle subtended between the line drawn from the centre of the femoral head to the centre of the tibial spines, then to the centre of the talus (hip-knee-ankle angle) [12], shown on a lower limb AP radiograph, which has inherent variability. [13,

14, 15, 16] Neutral alignment is defined as a 0-2° residual varus angle [17, 18], whereas kinematic or 'true varus' is defined as >5°. [10]

Alignment objectives of proper component position while respecting KA concepts and correcting the pre-operative varus while avoiding under- or overcorrection are achieved while attending to patient variables (e.g., degree of deformity and pre-operative ligamentous laxity), implant characteristics (e.g., thickness of the components and polyethylene used, rotation-plate or fixed-plate prosthesis) and surgical technique (e.g., use of intramedullary/extramedullary alignment guides). [19]

It is necessary to perform a tibial bone resection perpendicular to the meta-epiphyseal axis of the bone and the distal femoral bone cut in parallel and symmetrically to the tibial cut. [1, 7] A recent biomechanics study has shown that a tibial bone cut at 2° of varus in relation to the anatomical axis of the tibia is preferable to neutral, as it prevents lateral subsidence of the tibial component seen following poor load distribution on the bone-prosthesis interface. [20, 21]

A 2° varus cut is enough to distribute more load to the peripheral portion of the medial plateau itself, i.e., at the cortical bone, rather than to the relatively softer bone of the metaphyseal

portion of the tibial spine. Conversely, a $\geq 4^\circ$ cut of the tibia in the coronal varus plane leads to an increased risk of translation in the medial-lateral direction of the femoral shield-tibial plateau interface with consequent implant malfunction and higher rate of aseptic loosening and failure. [22]

With a varus angle larger than 5°, polyethylene wear negligible compared to the previous one aseptic loosening. [23]

Regarding tibial slope, an angle between 3° and 7° degrees results in correct prosthesis functioning during the flexion-extension transition, without compromising the anteroposterior and rotational stability of the knee. [24, 25, 26, 27] Always determine the slope based on the characteristics of the implant (rotation-plate or fixed-plate) and patient specifics such as the integrity of the anterior cruciate ligament or tension of the collateral ligaments. [28, 21]

With regard to the femoral component, proper kinematic alignment is achieved when it is positioned according to a distal cut of the femur, parallel to the tibial cut so as to guarantee the widest and most congruent support surface possible throughout the flexion-extension articulation of the knee.

A distal cut of the femur made in excessive varus or valgus will modify the final correction angle of the limb. An overly flexed or overly extended position of the femoral component in relation to the longitudinal axis of the femur will affect range of motion. Excessive lateral placement of the femoral component on the medial femoral condyle will result in more pronounced polyethylene wear over time relative to an implant placed more medially. [29]

It is possible to correct the initial deformity of the limb involved in order to achieve a satisfactory clinical result and the proper functioning of the joint and the implant, though tolerance for correction in UKA is less than in TKA. [30, 31, 32] Overcorrection shifts the load to a healthy contralateral femoral-tibial compartment, resulting in premature wear. Undercorrection may cause an increased mechanical stress on the implants (especially on the tibial side), increasing the risk of premature loosening. [33, 34] Comparison with a healthy contralateral knee may help gauge proper correction. [21]

Numerous scientific studies on correcting alignment in medial unicompartmental arthroplasty have shown that:

- The optimal correction of in medial UKA should result in a residual varus angle of between 2° and 3° [35, 36, 37].
- A residual varus between 0° and 2° is associated with an increased risk of undercorrection of the loaded limb and its consequences (see above) [38, 39].
- A residual varus larger than 7° results in an increased risk of implant failure due to polyethylene wear [40, 41] and aseptic component loosening (especially tibial loosening) [42, 35].

Take-home messages:

- KA is the best way to replicate knee joint biomechanics.

- In order to perform proper KA of the components, the tibial bone cut must be 2° varus with a distal femoral cut parallel to the previous one.
- A residual hip-knee-ankle angle between 2° and 3° under load is the goal in a medial unicompartmental knee replacement.
- Properly performed pre- and post-operative radiographs are fundamental to planning.

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Chapter 7: The importance of the lateral compartment in medial unicondylar knee arthroplasty - Johannes Beckmann

Progression of osteoarthritis in the lateral compartment remains among the most common reasons for revision of the medial UKA [13] and the second most common reason for loosening of the tibial or femoral component [2]. Failures of UKA is mainly seen in the first 5 years due to surgical error or incorrect indication. In contrast, development or progression of osteoarthritis in the lateral compartment is more likely to be observed in the mid- to long-term follow-up [3]. However, it should be noted that lateral compartment chondrocalcinosis or osteoarthritis were contraindications for implantation of UKA postulated by Kozinn and Scott in 1989 [1], and remain often followed.

The status of the lateral compartment may determine the suitability for a medial UKA. In an interesting MRI paper, despite preoperative changes in the lateral compartment as well as patellofemoral on MR imaging, there were no differences in postoperative outcome with implantation of a medial UKA with mobile-bearing inlays [4]. In contrast, in another study with mobile-bearing inlays, the preoperative condition of the lateral compartment is evaluated differently. Indeed, here it was shown to have a significant influence on the progression of osteoarthritis. Furthermore, the progression of osteoarthritis in the lateral compartment represented the most frequent reason for revision. However, a correlation between leg axis and progression of osteoarthritis could not be demonstrated [5]. Another study demonstrated a progression of osteoarthritis in the lateral compartment due to overcorrection into valgus with fixed-bearing inlays [6].

For surgical planning and detecting changes in the other compartments, both conventional X-ray imaging and MRI are available. CT should be used in selected cases due to a high radiation exposure. Bone-on-bone contact in the medial compartment and preserved patellofemoral and lateral compartments are indications for implantation of a medial UKA. MRI may overestimate pathology in the lateral compartment. Several studies demonstrated that overestimation does occur and that patients with abnormal changes on MRI in the lateral compartment can be safely treated with a medial UKA. There were no differences in survival or clinical results [16, 18, 19].

Independent risk factors for progression of osteoarthritis in the lateral compartment seem to be surgery on the dominant leg, implantation of large prostheses with size > 4, revision

surgery, and a tibiofemoral angle $> 5.5^\circ$ postoperatively. However, mild progression by one degree within the Kellgren-Lawrence score is commonly seen and not clinically relevance [7].

After implantation of a medial UKA, low rates of moderate or severe osteoarthritis (both 4,9%) in the lateral compartment were seen in the radiological control after 15 years. These patients had a lower Oxford Knee Score than those without or with mild osteoarthritis of the lateral compartment. However, the mean score of 36 still indicated a good result [8].

An MRI study found a correlation between the size of lateral osteophytes and loss of full-thickness cartilage defects on the tibial side [15]. Hamilton et al. showed in a study with a follow-up of 15 years that lateral osteophytes are not contraindicated for medial UKA. In the setting of full-thickness cartilage, there was no deterioration in long-term functional outcome or implant survival despite lateral osteophytes [14].

MRI may show meniscal pathology. In another study, patients with and without preoperatively detected lateral meniscal lesions were compared with regard to outcome after implantation of a medial UKA. After a minimal follow-up of 5 years, no significant differences were found with regarding to the functional scores as well as the mechanical leg axis and the positioning of the implant. The group with lateral meniscal lesions showed a tendency of slight varus alignment in the postoperative radiograph. Overall, no differences in outcome were observed if the patients were asymptomatic with their meniscal lesion preoperatively. Thus, implantation in patients with an asymptomatic lateral meniscal lesion remains indicated [20]. Some case reports describe lateral meniscal lesions after successful implantation of a medial UKA [21,22].

Concerning chondrocalcinosis, neither studies with fixed-bearing [9] nor mobile-bearing inlays [10, 11] revealed no difference in clinical or functional outcome, survival rate, or UKA failure rate between patients with and without chondrocalcinosis. Patients showed no exaggerated progression of osteoarthritis in the lateral compartment compared with patients without chondrocalcinosis. Aseptic loosening rates and anterior cruciate ligament insufficiency rates were also not increased. Only one study showed poorer prosthesis survival after 10 years in patients with histologically proven chondrocalcinosis [12]. A systematic review of 2021 showed that CPP crystals in tissue samples, synovial fluid, or the detection of calcifications on preoperative radiographs had no significant effect on postoperative functional outcome,

activity scores, or survival rate. Chondrocalcinosis also did not result in radiographic progression of osteoarthritis after UKA [17].

Take home messages:

- Early pre-operative changes in the lateral compartment and post-operative outcomes continues to be clarified, although not necessarily a hard contraindication for medial UKA;
- Progression of lateral compartment arthritis represents the most frequent reason for revision;
- UKA is a true KA procedure; slight varus alignment best replicates knee joint kinematics and decreases lateral compartment degeneration;
- MRI overestimates lateral compartment degenerative changes;
- Chondrocalcinosis is not a contraindication for medial UKA.

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Chapter 8: Patellofemoral status in unicompartmental knee arthroplasty - Andrea Parente

Historically, degenerative changes in patellofemoral joint was seen as an absolute contraindication to unicompartmental knee arthroplasty (UKA). [1] Patients who suffer from patellar discomfort, presenting focal or wide chondral lesions in either the medial or lateral patellar facets, were candidates only for total knee replacement (TKR).

Nowadays, several studies showed how debatable this issue is and how patellofemoral osteoarthritis is no longer considered an absolute contraindication to UKA.

Recently, Deckard et al [2] retrospectively analyzed 143 fixed bearing UKAs with a mean follow up of 24 months. Their study showed no correlation between patellofemoral joint (PFJ) disease severity and patient-reported outcomes measures at latest follow up with 93% of patients satisfied or very satisfied regardless of PFJ status.

Misir et al. [3] observed osteoarthritis (OA) progression in PFJ and lateral compartment after having performed medial UKA in 146 patients with ten years follow up.

Mild radiographic progression of 1 Kellgren-Lawrence (K-L) grade was seen in most of patients, but only the development of lateral compartment OA influenced postoperative outcomes. Risk factor for PFJ disease evolution were: PFJ OA before surgery, knee flexion contracture $>10^\circ$ and age > 60 .

Likewise, in lateral UKA PFJ degenerative disease seems not to be correlated to worse post operative outcomes. According to Fujita et al. [4] degeneration, tilt angle and lateral subluxation of the patella did not significantly increase after performing lateral UKA. Preoperative degeneration of PFJ did not have a negative influence on postoperative scores.

In 2019, Lim et al [5] prospectively followed 263 knees that underwent medial fixed bearing UKA for a mean of 10 years after surgery. The aim of the study was to assess functional outcomes and survivorship analysis of patients with significant radiographic evidence of preoperative PFJ OA. Patients with end-stage PFJ osteoarthritis (K-L grade 4) were excluded. They concluded that the presence of radiographic PFJ degeneration did not affect functional outcomes and implant survivorship after 10 years follow up. The only cause for revision was progression of lateral compartment OA.

The literature has also shown no significant differences between fixed and mobile bearing UKA in consideration of PFJ status and evolution after surgery.

In 2020, An et al. [6] evaluated 73 knees with preoperative PFJ OA and after implantation of an Oxford mobile bearing UKA with a mean follow up of 35 months. They demonstrated pre op PFJ status has no statistically significant effect on early functional recovery after surgery, but lateral PFJ OA was correlated to inability to complete squat and sit up.

In 2017 Hamilton et al [7] analyzed 805 Oxford phase 3 cemented UKA at 10 years follow up for functional outcomes and at 15 years for implant survivorship. Knees with PFJ lateral grooving or bone loss were excluded. Patients with isolated full thickness cartilage loss in the medial or lateral side of the PFJ or both experienced no differences in postoperative functional scores. Only in 6% of patients having full thickness lateral cartilage loss a difficulty in descending stairs was seen, which was not statistically significant. At 15 years there was no difference in UKA survivorship between patients with or without PFJ OA. Anterior knee pain was not a decisive factor as well. Finally, provided there is not severe damage to the lateral side of the PFJ, patellofemoral degenerative disease or anterior knee pain were not contraindications to mobile bearing UKA.

In 2019 Burger et al. [8] performed a retrospective review about the influence of preoperative degenerative changes in PFJ on the outcomes of fixed bearing UKAs. All UKAs were robotically-assisted with a minimum duration of follow up of 2 years and all patients with severe bone loss or grooving of the lateral patellar facet were excluded. A total of 639 knees were included in the study finding a good to excellent Kujala score independent of preoperative PFJ OA. Furthermore, neither patellar tilt nor PFJ malalignment influenced post operative scores in medial fixed bearing UKA.

Wang et al. agrees with a lack of correlation between anterior knee pain and mild to moderate degenerative PFJ changes, especially on the medial side, and poor postoperative outcomes after performing UKA, even though degeneration of the lateral PFJ can be a risk factor [9]. Berger et al. [10] declared in case of severe lateral PFJ degeneration UKA should be avoided. Indeed grade 3 and 4 according to Iwano classification in lateral PFJ were considered indications for combined patello-femoral and medial unicompartmental arthroplasty or total knee replacement.

Ji et al [11] retrospectively analyzed 336 knees stratified to two groups: patients with preoperative patello-femoral OA (PFOA) and patients without degenerative changes in PFJ (non-PFOA). After more than 5 years follow up 74,3% of PFOA and 75% of non-PFOA had no worsening in PFJ K-L. No statistically significant difference was found between these two groups. Lu et al. [12] in 2020 carried out a meta-analysis on the same topic identifying 8 studies for a total of 3975 knees where patients with severe bone loss of lateral PFJ were excluded. They demonstrated no significant difference between PFOA group and non-PFOA group in postoperative Oxford Knee Score (OKS). Moreover, moderate lateral PFJ OA did not seem to correlate to poor functional outcomes and patients dissatisfaction on the mid-term follow up.

Take home messages:

Perform medial UKA in patients with:

- Anterior knee pain without evidence of degenerative changes;
- Patellar tilt;
- Medial PFJ OA;
- Mild to moderate lateral PFJ OA;
- Focal osteochondral lesions of trochlea or patella.

Avoid medial UKA in patients with:

- Severe lateral PFJ bone loss;
- Subluxation of patella;
- Lateral patellar grooving.

Perform lateral UKA in patients with:

- Patellar shift;
- Lateral or medial PFJ OA;
- Patellar tilt.

No difference between standard and robotic assisted technique regarding PFJ status evolution;

In case of UKA contraindications consider TKA or Bicompartamental Knee Replacement (UKA + PFJ replacement - BKR). BKR has the same efficacy of TKA with less comorbidities.

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Chapter 9: Unicompartamental knee arthroplasty in the ACL deficient knee

- Paweł Skowronek, Agnieszka Bartyzel, Łukasz Dutka, Michał Skowronek

Historically, one of the contraindications for UKA was anterior cruciate ligament (ACL) insufficiency and anterior instability. However, many surgeons extent their indications to UKA and address anterior knee instability in one procedure. The aforementioned is due to the growing number of young patients with unicompartamental osteoarthritis (UOA), mainly medial osteoarthritis (MOA), who are more physically active, participate in sports and other high-impact activities that can increase the risk of developing knee OA due to knee trauma including ACL tear, meniscal and cartilage injuries.

Surgical management of MOA accompanied by ACL deficiency (ACL-D) is challenging. UKA performed in ACL-D knees results in higher failure rates, especially in young patients due to the altered joint kinematics and recurrent anterior translation of the tibia in relation to the femur. Increased polyethylene wear and consequent osteolysis are seen resulting from increased motion of the joint. Further, any instability increases the risk of dislocation of a mobile bearing [1,2]. Therefore, various strategies have been proposed including ACL reconstruction (ACLR), high tibial osteotomy (HTO) with or without ACLR, UKA with or without ACLR and TKA. TKA may be overly aggressive if the degenerative changes are restricted solely to the medial compartment, especially in the younger patient. It is also notable that there is a threefold higher rate of graft failure in ACLR combined with HTO than ACLR combined with UKA [3].

There are 2 possible scenarios of MOA and ACL-D. In older patients, who have lower activity levels, OA is the primary disease with secondary ACL deficiency and little to no instability. In these patients a UKA without ACLR can be considered while respecting these technical aspects: reduction of the tibial slope and tensioning of the collateral ligaments. Change of the posterior tibial slope contribute to tensioning of the collateral ligaments, its reduction increases collateral ligament tension. It is recommended that the posterior tibial slope should not exceed 7°.

In the second scenario, ACL tear and anterior instability is the primary concern. ACL injury prompts recurrent subluxation of the femur leading to wear of the posteromedial cartilage and medial meniscus and secondary degenerative changes in younger, active patients [4,5]. As ACLR is a frequent, validated procedure leading to complete recovery and return to

high level sports and UKA being an established treatment method for medial compartment OA, the combination of both these procedures can be successful [6].

Obtaining good clinical results require proper patient selection and experience in both procedures (ACLR and UKA). The ideal patients for the combined procedure include: medial non-inflammatory OA (bone-on-bone), a correctable intraarticular deformity, medial pain and instability related to ACL tear, and age less than 65. Extra-articular deformities are contraindications to UKA procedure; therefore such cases require possibly HTO or TKA to address the disease. Other contraindications to UKA and ACLR include: other coexisting ligamentous injury PCL, MCL or LCL, varus deformity exceeding 10° or uncorrectable passively deformity on clinical examination and previous HTO procedure [7].

UKA and ACLR may be performed as a one or two stage procedure. A staged procedure may be elected commencing with ACLR when instability is the main concern, with the UKA performed when pain due to OA arise. UKA and ACLR one-stage procedure is more time consuming and technically demanding, however requires just one procedure, less anesthesia, shorter recovery time and reduced costs. Rehabilitation following UKA-ACLR, however, is more difficult and time consuming.

Long-term outcomes after UKA and ACLR are limited. Studies are based on small groups, the materials used are not uniform, and the observations are at medium-term follow-up. However, excellent clinical outcomes have been observed, and clinical improvement was comparable to the control cohort of patients who underwent UKA with an intact ACL [8–10]. Albo et al. in a systematic review analyzed the outcomes of simultaneous ACLR and UKA in 169 patients with mean follow-up 6.3 years. The findings suggest that this combined procedure is safe and leads to improved functional and clinical outcomes, with an overall revision rate of 3.5% [11]. In all studies, authors express concern about the potential longevity of the results, but it has been reported that fixed-bearing medial UKA have a 96% survivorship at 10 years while mobile-bearing 91.4% at 14.5 years, others report the 5-, 10- and 15-year survival estimates were 97% (95% confidence interval [CI] 93–100), 92% (83–100), and 92% (83–100) respectively in mobile-bearing implants [5,12–14]. No significant clinical and radiological differences between mobile and fixed bearing implant designs were found at medium-term follow-up [15]. Postoperative stiffness, improperly positioned ACL graft tunnels secondary to prosthesis, graft impingement, undersizing of the tibial base plate (to avoid graft impingement), proximal tibia fracture and aseptic loosening of the tibial base plate are the encountered

complications [9,16]. In elderly patients who have not undergone ACL reconstruction with UKA, no significant difference was found in the literature regarding primary clinical outcomes such as postoperative revision rates, Tegner activity score, and Oxford Knee Score between ACL-D and ACL-intact knees. This suggests that UKA alone may be a suitable treatment option for these patients [17–19].

Summary

Treating patients with MOA and ACL-D knee is highly demanding. Experience in both UKA and ACL-R procedures is necessary to achieve predictable good outcomes. In older patients above 65 with secondary ACL injury to OA, UKA can be performed without ACL-R by correctly performing the surgical technique while avoiding an increase in posterior slope above 7°. In young patients with OA secondary to ACL injury, UKA and ACLR should be performed. Such procedure should be considered as an alternative to TKA in young and active patients, aiming to preserve knee function and bone stock.

Take home messages:

- ACL insufficiency is not a contraindication for UKA.
- In young patients (under 65 yo) with OA secondary to ACL injury, UKA and ACLR should be performed.
- In older patients above 65 with secondary ACL injury to OA, UKA can be performed without ACLR by correctly performing the surgical technique while avoiding an increase in posterior slope above 7°.
- No significant clinical and radiological differences between mobile and fixed bearing implant designs.
- Survivorship, clinical outcomes and improvement are comparable to patients who underwent UKA with an intact ACL.

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Chapter 10: Unicompartmental Knee Arthroplasty after prior Knee Surgery - Theofylaktos Kyriakidis^{1,2}, Ioannis Samaras¹

1. Department of Orthopaedic Surgery and Traumatology, Erasme University Hospital, Université Libre de Bruxelles, Route de Lennik 808, 1070 Brussels, Belgium

2. 2nd Department of Orthopaedic Surgery and Traumatology, Aristotle University of Thessaloniki, "G. Gennimatas" General Hospital, Ethnikis Aminis 41, 54635 Thessaloniki, Hellas

Using the classical indication criteria described by Kozinn and Scott [8], a previous osteotomy was considered a contraindication for UKA, as it might negatively influence clinical outcomes and prosthesis survivorship. Indeed, performing UKA following HTO is a complex and challenging procedure due to potential technical difficulties, including soft tissue scarring, modified tibial slope, poor bone stock, altered patellar height, and ligamentous laxity [3, 11, 17]. Despite demands of the procedure, recent literature demonstrates that unicompartmental knee arthroplasty after previous surgery is a valuable treatment option with encouraging results.

More precisely, Schlumberger et al. [16] retrospectively evaluated thirty patients treated with medial UKA after failed prior HTO. They concluded that prior HTO is not a contraindication for medial UKA because most patients presented good-to-excellent midterm results with a survival rate of 93%. They also suggested avoiding excessive mechanical valgus axis and that patient selection and accurate evaluation of medial laxity, preoperative mechanical axis, joint line convergence, and proximal tibial geometry are crucial. Legnani et al. [10] performed a systematic review focusing on medial UKA after HTO. They also found that UKA following failed HTO appears to be a safe and effective procedure, providing satisfying outcomes and limited complications in most cases.

In another recent study, Parente et al. [11] compared 24 post-HTO UKAs to 30 simple UKAs. They found that UKA improves clinical and functional outcomes in both groups, demonstrating that performing UKA with a previous HTO is a safe and effective procedure. However, an HTO was a determinant for having reduced postoperative clinical and functional outcomes after UKA. The same authors [12] performed a retrospective study comparing clinical, radiological, and functional results between UKA and TKA in knees with a previously failed opening wedge HTO. They reported that performing UKR is a safe and effective procedure that leads to excellent clinical outcomes with no statistically significant difference compared to TKA. Regardless, TKA has a more neutral mechanical axis with less residual varus. Similarly, Valenzuela et al. [17] reported no statistically significant differences in clinical

and radiological outcomes following UKA and TKA after HTO or primary UKA with a mean of 6 years follow-up. Thus, a prior HTO status does not affect the outcomes of a UKA, which provides results comparable to those of TKA after HTO or primary UKA.

A recent systematic review by Vasso et al. [18] suggests that, despite a previous HTO, it is final limb alignment that determines outcomes. The authors reported that the final limb alignment in UKA is determined by the thickness of the implant relative to the bone excised and that UKA aims to restore joint kinematics by properly tensioning the MCL and not working to correct the limb axis. Many patients have varus alignment before developing medial OA because of constitutional tibia vara (an extra-articular deformity), resulting in varus alignment post-operatively. Therefore, it might be thought that patients with preoperative varus deformity (or flexion contracture) $> 15^\circ$ are not suitable candidates for UKA since the residual postoperative axis will still exceed 8° to 10° and lead to possible failure due to polyethylene wear and/or implant loosening.

Previously, Rees et al. [14] reported that medial UKAs failed due to overcorrection of a varus deformity. UKA can correct an intra-articular varus deformity. An HTO, however, addresses the extra-articular varus deformity and can result in valgus leg alignment, increased lateral compartment loading, and implant failure. A recent consensus statement by Berend et al. [1] concluded that a previous high tibial osteotomy with neutral or valgus deformity is still a contraindication for UKA. In contrast, undercorrected HTO is no longer a contraindication. There was disagreement, however, on the magnitude of under-correction following HTO that might be acceptable. In conclusion, recent literature suggests that previous HTO is no longer a blanket contraindication to performing UKA, but surgeons should avoid low-volume use of UKA to optimize outcomes for their patients [13].

UKA after arthroscopy is another common dilemma, given the frequency of arthroscopy. It is often performed to deal with mechanical issues due to traumatic or degenerative meniscal tears, ligament injuries, and delayed arthroplasty. Even so, 15-20% of these patients will progress to osteoarthritis and ultimately receive unicompartmental joint replacement in the next two years [2]. To date, there is a lack of recent literature, and only a few studies analyzed the effect of previous arthroscopic surgery on clinical outcomes and survivorship of the UKA.

Fassihi et al. [4] reported that patients who underwent UKA within two years of arthroscopy are associated with an increased rate of UKA conversion to TKA and a higher rate of UKA failure from aseptic loosening. The authors analyzed the three largest subcategories of arthroscopic surgery performed within two years prior to UKA, and found that patients with prior arthroscopic general/soft tissue procedures were at significantly increased risk of UKA conversion to TKA relative to patients with previous arthroscopic meniscal procedures. They reported that this is most likely due to confounding variables rather than a direct association, as the general/soft tissue group was primarily comprised of patients undergoing arthroscopic lysis of adhesions and synovectomy. This procedure may be performed for relative contraindications for UKA (i.e., lysis of adhesions for flexion contracture). Hence, it is possible that an extensive portion of this patient group would be improper for UKA and rapidly progressed to requiring TKA. Fournier et al. [5] investigated the risk factors related to stiffness, a relatively rare complication of UKA. Although there was no statistically significant difference, patients with prior meniscectomy had twice the risk of presenting stiffness.

In another study, Frank et al. [6] included patients with a history of a prior open or arthroscopic cartilage and/or meniscal restoration procedure and subsequent ipsilateral UKA or TKA. All cartilage patients were matched with control patients for demographic characteristics and arthroplasty type and followed for at least two years. They concluded that patients undergoing arthroplasty after prior failed cartilage/meniscal restoration have significantly less pain relief, lower functional outcomes, and less improvement following partial or total knee arthroplasty. They also reported that knee arthroplasty may be an effective procedure in patients who fail cartilage restoration, but expectations must be tempered from primary knee arthroplasty's almost uniformly excellent outcomes.

Recently, Haffar et al. [7] compared forty-five patients who underwent medial UKA after prior anterior cruciate ligament (ACL) reconstruction matched by age, gender, preoperative function scores, and body mass index to ninety patients who underwent UKA with an intact ACL. All patient-reported outcomes measures (PROMs) improved significantly, with no differences between groups at a mean of 3.6 years follow-up. Hence, these authors concluded that a previously reconstructed ACL does not appear to compromise the short-term functional outcomes of UKA; however, a higher rate of minor complications and progression of lateral compartment arthritis was noted.

Take Home Messages:

- Previous HTO is not considered a blanket contraindication to performing a medial UKA, except in cases of postoperative neutral or valgus deformity.
- UKA is a safe and effective procedure following a previous HTO, but may be technically demanding.
- Surgeons should avoid the low-volume use of UKA to optimize outcomes.
- Patients who underwent knee arthroscopy within two years of UKA are at increased rate of conversion to TKA.
- UKA is an effective procedure in patients who fail cartilage restoration, but may have significantly less pain relief, lower functional outcomes, and less improvement than patients after a primary partial knee arthroplasty.
- A previously reconstructed ACL does not compromise the functional outcomes of UKA.

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Chapter 11: Unicompartimental knee replacement for osteonecrosis of the knee

- Matteo Marullo, MD.

Introduction

Osteonecrosis (ON) of the knee was initially described by Ahlback et al. in 1968. It encompasses three different variations: spontaneous osteonecrosis of the knee (SPONK), which is the most common category, secondary osteonecrosis, and post-arthroscopic osteonecrosis [1,2].

SPONK typically presents as an unilateral disorder in the 6th decade of life, with a higher incidence seen in females [3]. The medial femoral condyle is affected in 94% of cases [4].

It is not associated with any known risk factors; its etiology is recognized as the result of insufficiency fractures in osteopenic bone, eventually leading to an effusion, bone edema, and necrosis [5].

Secondary ON typically presents before the 4th decade of life and frequently involves multiple lesions in several joints concurrently [4]. It is bilateral in 80% of cases [4].

Secondary ON has numerous well-recognized predisposing factors that can be categorized into direct causes, including sickle cell disease, myeloproliferative disorders, and Gaucher's disease, and indirect causes such as alcohol, obesity, and corticosteroid use. Alcohol abuse and steroid usage likely the cause of over 90% of cases of knee ON [4]. The true prevalence of secondary ON is difficult to ascertain and may well be underreported as patients present with end-stage osteoarthritis after undiagnosed osteonecrosis.

Post-arthroscopic osteonecrosis of the knee is an uncommon complication after knee arthroscopy. Its incidence is 0.2-1.5%; men and women are equally affected, with a mean age of 58 years [6]. The etiology of post-arthroscopic ON is debated. Altered knee biomechanics after meniscectomy could be a predisposing factor; the role of radiofrequency or mechanical shavers is not yet clear in the onset of post-arthroscopic ON [7].

Classification and indication for surgery

On radiographs, ON is initially recognized as a flattening of the medial femoral condylar joint surface and progresses to radiolucent osteochondral bone defect at the subchondral zone. On MRI,

findings like bone marrow edema, subchondral crescent linear focus on T1 and potentially T2 sequences, focal epiphyseal contour depression, or subchondral low signal may be seen [8].

ON is commonly classified in four stages following the Koshino et al classification: (1) knee symptoms with normal radiographic finding, (2) flattening in the weight-bearing area and subchondral radiolucency surrounded by osteosclerosis, (3) extended radiolucency and subchondral collapse, and (4) osteoarthritis [9].

The size of the lesion measured upon X-rays in case of ON represents a prognostic factor and gives indication for treatment, as lesions $<3.5 \text{ cm}^2$ usually regress with non-surgical management, lesions of 3.5 to 5.0 cm^2 may or may not regress, while large lesions $>5 \text{ cm}^2$ usually lead to condylar collapse [4]. Consequently, surgical management should be considered when patients do not improve clinically or radiographically after 3 months of nonoperative treatment, as well as in patients who present with osteonecrotic lesions larger than 5 cm or involving more than 50% of the medial femoral condylar surface [10]

Non-surgical management is intended only for small lesions and includes non-weight bearing or protected weight bearing with a knee brace, nonsteroidal anti-inflammatory drugs (NSAIDs), analgesics, and judicious bisphosphonates.

Surgical management includes arthroscopic debridement, core decompression, subchondroplasty, osteochondral autograft, high tibial osteotomy, and unicompartmental (UKA) or total knee arthroplasty (TKA).

Unicompartmental knee replacement for osteonecrosis of the knee

The first reports on medial UKA for osteonecrosis of the medial femoral condyle were published in the late 1980's by Cartier and Hernigou [11,12]. In the mid 1990's, another pioneer of partial knee replacement, Marmor, published a case series of 34 UKA implanted for ON of the medial femoral condyle, with good results in 30 (89%) [13].

The first paper comparing UKA for medial ON and for primary osteoarthritis (OA) was published in 2005 by Langdown et al. [14]. The ON group accounted for 29 patients; the OA group consisted of 28 knees with medial OA. A mobile-bearing cemented UKA was implanted in all cases. Groups were matched with respect to age, sex, follow-up (5 years on average). There were no revisions in any groups and patients in both groups showed comparable Oxford knee scores and were equally satisfied with the clinical outcome.

The first medium- to long-term outcomes of UKA in ON were supplied by a German research group in 2011 [15]. They retrospectively reviewed 52 medial UKA, showing a survival rates of 93.1% after 10 years and 90.6% after 15 years; 97.4% of patients were satisfied or very satisfied by the procedure.

The study with the longest follow-up was performed in France and accounted for 28 UKA evaluated at a mean follow-up of 21 years (range, 15-26 years) [16]. The survival rate of the implants was 92% after 15 years and 83% after 26 years. No survivorship difference was found between the patients suffering from SPONK or secondary ON of the knee (83% vs 90%, $P = 0.6$). Knee Society Scoring system knee and function Scores had a stable improvement even at the latest follow-up.

Chalmers in 2018 presented the clinical results and the survivorship of 46 medial UKA for primary or secondary ON [17]. They found that secondary osteonecrosis was found to be a significant risk factor for reoperation, leading to a survival rate of 89% at 5 years and 76% at 10 years; instead, UKA for primary osteonecrosis had a survivorship of 93% at both five and ten years.

A recent systematic review and meta-analysis compared the clinical results and survivorship of medial UKA for ON or for primary OA [18]. They found that the incidence of UKA revision for any reason was significantly higher in ON than in OA, but there were no differences in the risk of revision due to aseptic loosening. When selecting only high-quality studies, the risk of overall revision was similar in ON and OA groups. Subgroup analysis revealed no differences in survivorship between ON and OA after cemented mobile and fixed bearing UKA; only one study reporter results of uncemented UKA, showing higher failure rate in ON group. There were no differences in clinical outcomes for UKAs after ON or OA.

Two studies directly compared the results of UKA to TKA for ON [19,20]. In 2005 Radke et al. retrospectively evaluated 23 UKAs and 16 TKAs after a mean follow-up of 5 years [19]. They found better short-term clinical results for UKA; however, at the final follow-up TKA showed better clinical results and higher survivorship. The higher revision rate of UKA was attributed to poor bone stock and secondary osteoarthritic changes in the contralateral compartment. Notably, these results were confounded by a limited number of cases and the lack of contemporary implant design and technique, as all UKAs were implanted before 1988.

In 2020, Flury et al. compared 37 UKAs and 34 TKAs for primary ON of the medial femoral condyle [20]. The two groups did not differ regarding age, body mass index and percentage of the condyle involved by the osteonecrotic lesion. After a mean follow-up of 6.6 years, the UKA group

showed better WOMAC and KSS scores compared to the TKA group; there were no differences in complication rate between groups. No correlation was found between necrotic lesion size and failure rate.

Conclusions

UKA in the treatment of medial ON of the knee is a valid option with excellent clinical results and high survivorship, even at a long- time follow-up. The survival rate is comparable, if not better, to that of UKA for primary OA, especially in the case of primary ON. Even if ON of the medial femoral condyle could affect the anchoring zone of the femoral component, it apparently has no negative effects on the survival rates of the implants.

In cases of secondary ON, a total knee replacement is the preferred treatment and not a UKA, due to the high risk of ON progression in other compartments of the knee.

Take home messages:

UKA should be considered for isolated ON of the medial compartment if one of the following situations is present:

- grade 3 or 4 ON according to Koshino classification [9], in which an extended radiolucency, a subchondral collapse or a clear OA is present.
- osteonecrotic lesions larger than 5 cm² or involving more than 50% of the surface of the medial femoral condyle in the coronal plane
- osteonecrotic lesions < 5 cm² but non-responsive to three months of conservative treatment

In case of secondary ON, a total knee replacement is suggested.

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Chapter 12: The Role of Robotics on UKA - Bruce Gomberg

Types of robotic assistance in UKA

Robotic systems used in arthroplasty are classified into 3 types: passive, semi-active, and active systems. A passive system provides resection guidance and allows unassisted bone resections without assistance. A semi-active system provides tactile feedback and establishes the operative zone for the surgeon that enhances use of the burr or saw. An active system performs resections without the surgeon's direct intervention. Although many robotic systems have been developed, the most successful and widely used type at the time of this writing has been the semi-active systems.¹

Rational for using robotics in UKA

It's been established that UKA survivorship and functional outcomes are extremely sensitive to even small changes in component positioning. Therefore, the accuracy and precision that robotic assisted surgery can potentially deliver precision as an attractive adjunct to the traditional UKA procedure.

Robotics is used in UKA to enhance precision

Technological advancement has always been part of the evolution of knee arthroplasty. The most recent advancement is the addition of robotics to perform specific pre-operative planning and implant positioning. This is especially salient in unicompartmental knee arthroplasty, which has had a history of increased revision rates and decreased long-term survival rates compared to total knee arthroplasty.² In the case of unicompartmental knee arthroplasty, several variables that influence outcomes lend themselves particularly to the use of robotics, namely: implant positioning, restoration of the joint line, soft tissue balancing, limb alignment, and implant sizing.²

The advantages of robotics specifically are:

Assistance in pre-operative planning

With CT and image-based robotic systems, 3-dimensional pre-operative planning may be available. Intraoperatively, it is possible to assess ligament tension, cartilage height, and implant positioning and adjustments.

Joint line preservation

A recent publication demonstrated that robotic assisted UKA had better joint line restoration than conventional UKA and this was due to less distalization of the femoral component, while no difference in the tibial resections were found between groups.³

More accurate and reproducible

Kayani 2019⁴ noted several studies showing that robotic assistance leads to better and more reproducible implant positioning. This report noted that implant position was more aligned with the pre-operative plan and the joint line was more aligned with the native joint line.

Several studies have demonstrated increased accuracy and decreased variability in the positioning of one or both components of UKA.^{5,6} Overall, robotic assistance has been increasingly common in performing arthroplasty.⁷

The disadvantages of robotics specifically are:

Cost

Adding technology always increases cost and that is also the case for robotic assistance in unicompartmental knee arthroplasty. Several studies show that, over time, a surgeon may find cost parity when adding the potential benefits that have yet to be demonstrated. However, there is increased cost associated with pre-operative imaging, anesthesia time, recovery room time, and supplies demonstrated by Kolessar.⁸

Learning curve

There is a clear learning curve associated with the adaptation of new technology. During this period, the operation takes more time and may have an effect on implant sizing, but not overall patient outcome. It may take anywhere from 6-11 cases to become proficient.^{9,10}

Survivorship & outcomes

While attractive for its help with precision and accuracy, robotic assistance has yet to prove any benefit in patient function, recovery, outcomes, revision rates and implant survival rates.^{11, 12, 13,}
¹⁴ At the time of this writing, robotics is an available technology that assists surgeons in data collection and technique and promises to enhance the surgery, but in a manner that has yet to be clarified.

Take home messages:

- Robotics in UKA is still developing and used by a minority of knee surgeons;
- Robotics in UKA can improve precision of the bony resections, implant positioning and implant sizing;
- Robotics in UKA has some disadvantages, including cost, added OR time and a steep learning curve;
- Robotics in UKA has not lead to improvement of any meaningful clinically meaningful variable, like implant survival and patient outcomes.

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