



# Chapter 5

## UKA Computer Navigation

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**Abstract** Several factors are involved in the failure of unicompartmental knee arthroplasty (UKA), including the patient's age, anterior cruciate ligament deficiency, and alignment. To address these failures, a computer-aided navigation system that consistently provides accurate measurements was developed to reduce the errors committed with conventional UKA. The undercorrection with a minor varus alignment produced by this system provides appropriate outcomes and longevity for UKAs. The computer navigation system thus offered a procedure to attain optimal alignment. Although a learning period is required for computer-assisted surgery, the computer-assisted UKA produced comparable range of motion and WOMAC and Oxford scores with fixed-bearing UKA implantation.

**Keywords** Unicompartment knee arthroplasty · UKA · Longevity · Outcomes · Computer-assisted surgery · Navigation · Alignment

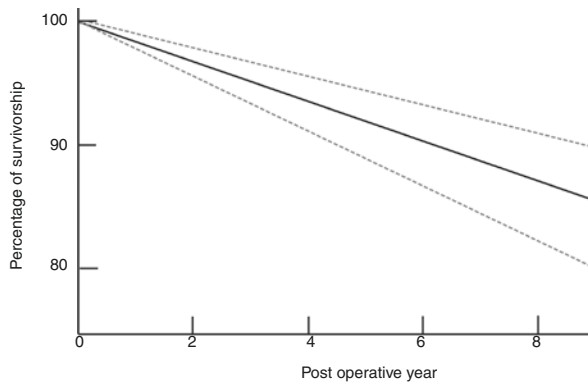
### 5.1 Introduction

Unicompartmental knee arthroplasty (UKA) provides a less invasive alternative to total knee arthroplasty (TKA) in selected patients [1]. Minimally invasive surgery (MIS) with a small incision and less damage has gained popularity for UKA. MIS has the advantage of a shorter recovery period and faster healing than TKA [2]. Joint registries indicate that MIS UKA was performed for at least half of the UKA procedures [3, 4]. As the number of UKAs has increased, however, it has led to an increased number of failures. Early reports of UKA with this technique showed higher failure rates than expected. For example, 43 (8.3%) of 517 medial MIS UKAs with fixed-bearing implants had reportedly failed at 6 years (Fig. 5.1) [2], which is in accord with recent orthopedic literature. The major reason for this failure was aseptic loosening (19/43, 44%), followed by progressive arthritis of the lateral compartment. Obesity has also been reported as a reason for UKA failure [5]. Although comparable revision rates were found in mobile and fixed UKA designs, progressive

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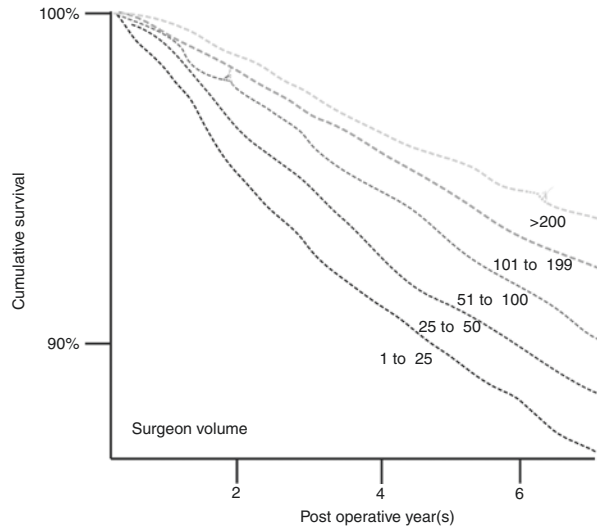
**Fig. 5.1** Postoperative survival of fixed-bearing unicompartamental knee arthroplasties (UKAs) (Depuy, Johnson & Johnson Company, New Brunswick, NJ, USA). The dark linear plot represents the survival rate of unicondylar implants over an 8-year follow-up period. The dashed lines show the 95% confidence interval. Hamilton et al. reported that revision rate was only 8.3% (43/517) of cases with fixed-bearing UKAs at 6 years. This figure has been modified based on data from the Hamilton et al. study [2]

arthritis was seen somewhat less frequently with mobile implants (0.23%) than with fixed implants (0.29%) [6]. An oversized femoral component or patellofemoral impingement was reportedly related to promote progression of patellofemoral osteoarthritis [7], although there was no significant difference in revision rates between Oxford III UKAs with and without progressive patellofemoral osteoarthritis [8]. It is well established that the high failure rate of UKA is associated with anterior cruciate ligament (ACL) deficiency [9], although other causes remain but are controversial. Age may affect the survivorship of UKAs, which is based on two joint registries and prior studies having reported significantly higher revision rates for UKAs in young patients [3, 4, 10, 11]. In contrast, some independent cohorts showed that age did not relate to UKA survival [1]. An analysis of 23,400 medial cemented UKAs showed that the institutional and surgeons' case volumes had an effect on the revision rates following UKA (Fig. 5.2). These results suggested that there should be at least 13 [12] to 23 [13] UKAs performed per year before better outcomes could be expected.

Alignment was also associated with UKA failure. Overcorrected valgus (hip–knee–ankle angle  $>180^\circ$ ) was associated with a high risk of degenerative changes in the opposite compartment, and undercorrection in varus deformity (hip–knee–ankle angle  $<170^\circ$ ) increased polyethylene wear and tibial component loosening [14]. Excessive stress on the supporting cancellous bone can cause loosening and failure. Sawatari et al. reported that excessive varus alignment led to cancellous bone stress [15]. The short-term survival study by Vasso et al. showed better outcomes for minor varus alignment than for neutral or close-to-neutral alignment. They found that 70% of UKA deformities were not fully correctable to neutral alignment [16]. The full extension of correctability of varus deformity could be determined only after removing osteophytes [17].

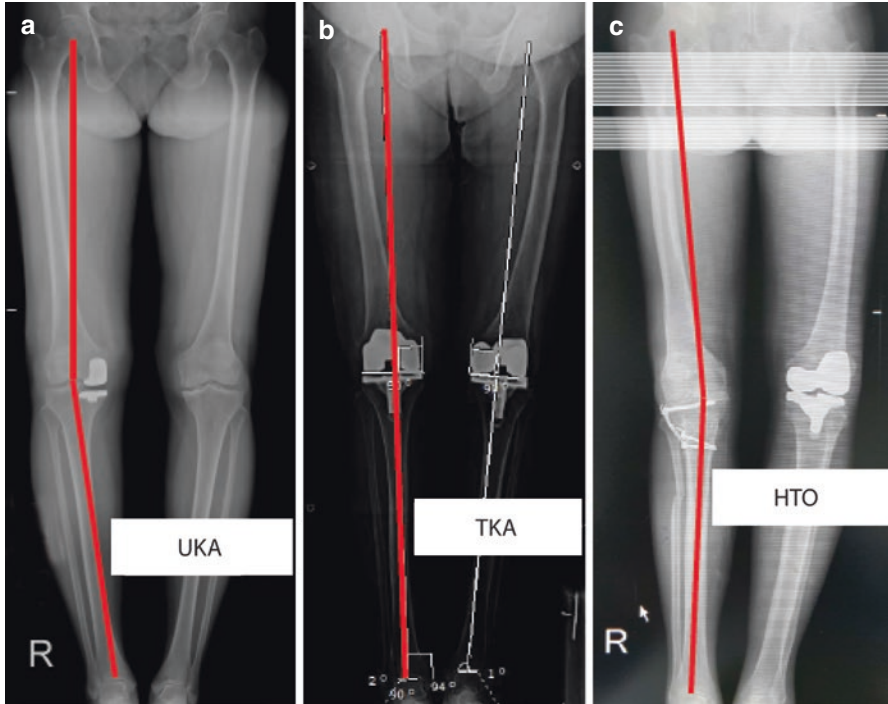
Alterations in tibiofemoral kinematics have implications for the cumulative survival rate of UKA prostheses. The highest rate of implant survivorship was found

**Fig. 5.2** Influence of the institutional and surgeon case volumes on the revision rate of unicompartmental knee replacement (UKR). The higher-volume of institutional and surgeon case rates produced higher cumulative survival rates. At least 13 such procedures per year have been suggested for better UKR outcomes. This figure has been modified based on data from the Baker et al. study [12]



with a tibiofemoral alignment of  $4^{\circ}$ – $6^{\circ}$  of valgus [17]. Overstuffing increased valgus at full extension and did not improve the tibiofemoral kinematics [18]. A posterior slope of the tibial implant must also be considered as a factor in UKA failure. Particularly, a compromise between physiological sagittal translation and excessive translation was detected in the posterior slope of tibial implants between  $3^{\circ}$  and  $7^{\circ}$  [19]. This notion was supported by the evidence that the posterior slope over this range would increase ACL stress, and frequent ACL ruptures occurred at slopes of  $>13^{\circ}$  [19]. The wear rate of tibial prostheses was significantly decreased at slopes of  $0^{\circ}$ – $4^{\circ}$ , whereas a slope of  $4^{\circ}$ – $8^{\circ}$  shows no difference [20]. Thus, procedures that restored appropriated alignment were needed to prevent UKA failure.

The principle of restoring alignment consists of undercorrection, neutral correction, and overcorrection (Fig. 5.3). The traditional concept of TKA is to restoration neutral limb alignment for good outcomes. While the better UKA outcomes were obtained with under neutral alignment correction. It is essential that restoration of the alignment has undercorrection without ligament release, thereby leading to increased surgical efficiency when using the computer-assisted system. Jenny et al. showed that computer-assisted navigation achieved a higher rate of perfect alignment than conventional surgery (60% vs. 20%), including the coronal femorotibial mechanical angle and both coronal and sagittal orientations of the femoral and tibial components [21]. Several recent studies have suggested that navigation could significantly improve positioning of the posterior slope in the tibial component over that achieved with conventional UKA methods ( $p = 0.04$ ) [22]. After a 10-year follow-up, UKA with navigation showed better outcomes regarding coronal alignment and clinical scores [23]. The Australian Joint Replacement Registry indicated that TKA with navigation had lower rates of revision than were achieved with conventional TKA [24], although this information was still lacking for UKAs. This evidence clearly suggested that the computer-assisted system could play an essential role in improving the restored alignment.

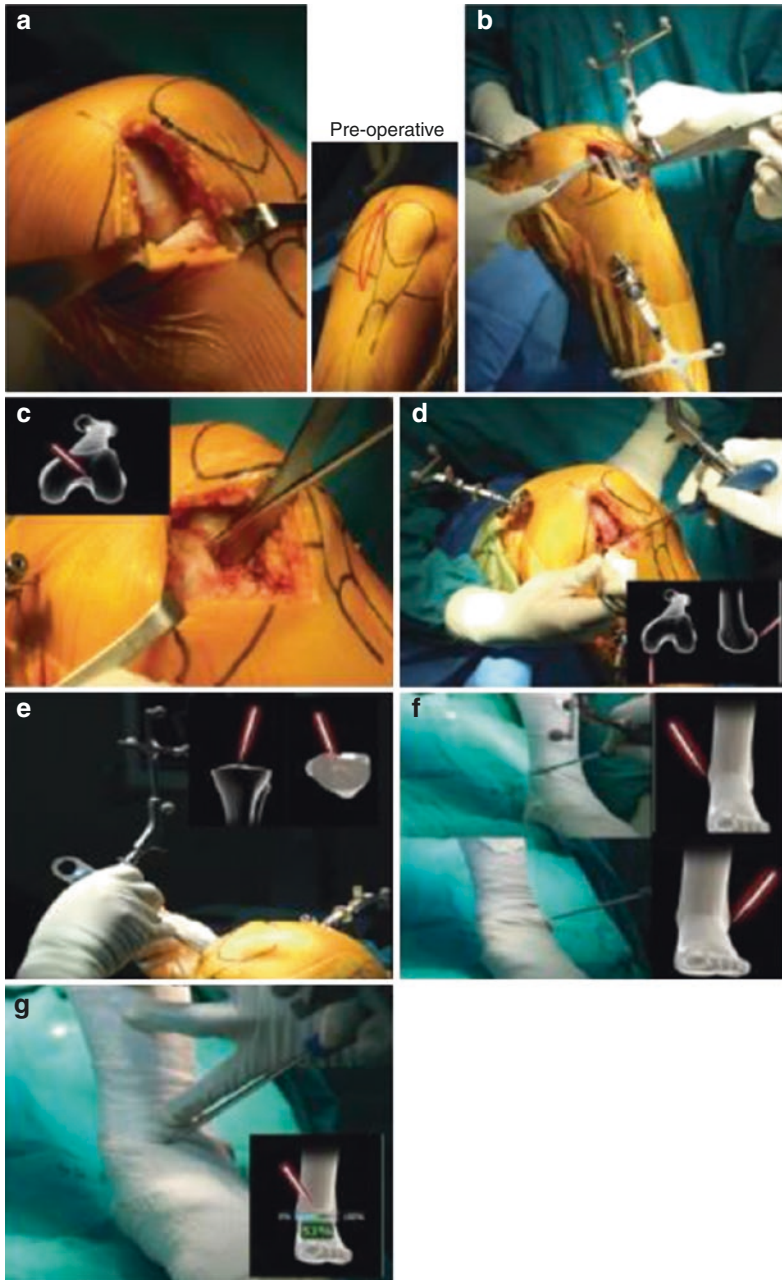


**Fig. 5.3** Restoration of alignment. (a) Undercorrection in unicompartmental knee arthroplasty (UKA). (b) Neutral correction in total knee arthroplasty (TKA). (c) Overcorrection with high tibial osteotomy (HTO)

## 5.2 Surgical Technique

Our MIS technique included an imageless navigation system (OrthoPilot 3.0; B. Braun Aesculap, Tuttlingen, Germany). The UKA technique is similar to that of Jenny et al. [25]. For navigated UKA, it is mandatory to carry out adequate preoperative planning based on radiographic images, as is done when using the manual technique.

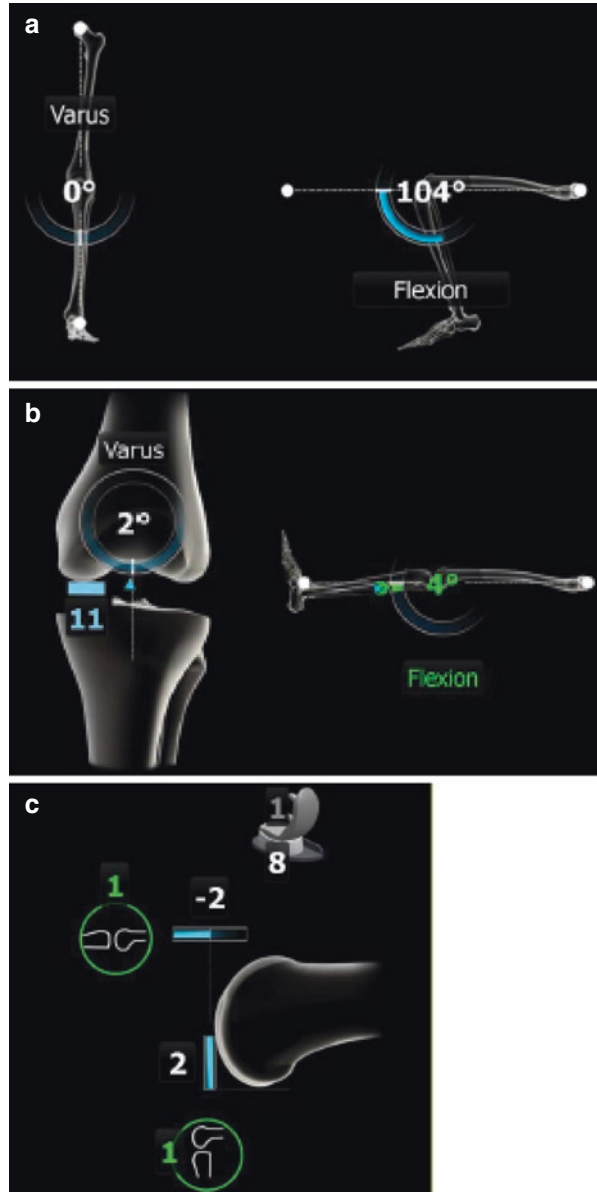
The skin incision is made via a medial parapatellar approach (Fig. 5.4a). Two infrared localizers are fixed on the distal femur and the proximal tibia (Fig. 5.4b). Registration of the femur and tibia was performed by touching the landmark points with a pointer at the knee center, the most distal point of the medial femoral condyle, the posterior point of the femoral condyle, the proximal tibial center and tibial plateau, the medial and lateral malleoli, and the center of the ankle joint (50% of the anterior ankle) (Fig. 5.4c–h). Kinetic registration of the hip center is performed by circumduction, flexion–extension, and rotation of the hip. These registration steps are used to define the mechanical axes of the femur and tibia in both anterior and sagittal views (Fig. 5.5a). The restoration of alignment or reducibility of the



**Fig. 5.4** Minimally invasive surgery navigated technique. The skin incision is made via a medial parapatellar approach (a) and restoration of the infrared localizer (b). Anatomical registry was then performed at the knee center (c), the most distal point of the medial femoral condyle and posterior point of the femoral condyle (d), proximal tibial center and tibial plateau (e), medial and lateral malleoli (f), and center of the ankle joint (50% of the anterior ankle) (g)

deformation can be assessed by the mediolateral joint laxity test, wherein the joint is stressed on the opposite side from the opening. A localizer is then placed on the tibial cutting block (Fig. 5.5b), and the proximal tibial resection is guided using the navigated cutting block, with the position controlled using a freehand technique.

The medial meniscus and osteophytes are removed. The accuracy of each resection is verified by a navigated plate. The femorotibial gap is then measured by



**Fig. 5.5** Simulation display during computer-assisted surgery with OrthoPilot 3.0 software (B. Braun Aesculap, Tuttlingen, Germany). (a) Simulated mechanical axes of the femur and tibia in both coronal and sagittal views are shown after anatomical registration. (b) The planning screen also shows both tibial and femoral resections. (c) They consist of coronal and sagittal orientations, high distal and posterior resections, and thickness of the tibial component mediolateral laxity

applying a laminar spreader at  $0^\circ$  and  $90^\circ$  of knee flexion. The planning screen of the femoral resection consists of coronal and sagittal orientations, the thickness of the distal and posterior resections, thickness of the polyethylene liner, and mediolateral laxity (Fig. 5.5c). These data can be virtually adjusted to obtain appropriate conditions. When the values meet the surgeon's preference, the UKA components are cemented and implanted in the patient. The final axis correction is then checked again by the navigation system.

In all, 32 patients underwent UKA with implantation of a fixed bearing (Univation<sup>®</sup>, B. Braun Aesculap) at Rajavithi Hospital from June to December 2015. We used the classic technique of tibial cutting at a  $0^\circ$  slope in 17 patients and an anatomical technique at a  $3^\circ$  varus slope in the other 15 patients. The range of motion (ROM) and Oxford and WOMAC scores were collected before and after surgery.

A student's paired *t*-test was used to compare the two treatments. Differences were considered statistically significant at  $p < 0.05$  and/or  $p < 0.01$ .

### 5.3 Results

The characteristics of both patient groups were comparable for age, weight, height, and body mass index (Table 5.1). The classic technique produced a significant difference between the preoperative and postoperative ROMs ( $p = 0.019$ ), whereas there was no difference in the other group (Table 5.2). There was no significant difference in the postoperative ROMs between the two techniques ( $p = 0.846$ ).

Both the classic and anatomical techniques significantly improved both the WOMAC and Oxford scores ( $p < 0.01$ ), compared with the preoperative baseline

**Table 5.1** Patients' demographics in the classic (tibial cutting at  $0^\circ$ ) and anatomical (tibial cutting at  $3^\circ$ ) groups

Characteristic	Classical technique ( $n = 17$ )	Anatomical technique ( $n = 15$ )	<i>p</i> -value
Age (year)	$60.9 \pm 5.1$	$58.9 \pm 4.5$	0.75
Weight (kg)	$67.5 \pm 12.5$	$73.1 \pm 8.6$	0.83
Height (cm)	$156.7 \pm 6.8$	$162.0 \pm 5.4$	0.82
BMI ( $\text{kg}/\text{m}^2$ )	$25.1 \pm 5.1$	$22.1 \pm 7.2$	0.69

**Table 5.2** Influence of the two techniques (classic tibial cutting at  $0^\circ$ , anatomical cutting at  $3^\circ$ ) on range of motion

Technique(s)	Pre-operative ROM degree (Mean)	Post-operative ROM degree (Mean)	<i>p</i> -value
Classical technique ( $n = 17$ )	115	123	0.019
Anatomical technique ( $n = 15$ )	121	122	0.667
<i>p</i> -value	0.032	0.846	

**Table 5.3** Effects of the two techniques (classic tibial cutting at 0°, anatomical cutting at 3°) on WOMAC scores

Technique(s)	Pre-operative WOMAC score (Mean)	Post-operative WOMAC score (Mean)	<i>p</i> -value
Classical technique ( <i>n</i> = 17)	73.60	25.67	<0.001
Anatomical technique ( <i>n</i> = 15)	72.29	22.36	<0.001
<i>p</i> -value	0.512	0.467	

**Table 5.4** Effects of the two techniques (classic tibial cutting at 0°, anatomical cutting at 3°) on Oxford scores

Technique(s)	Pre-operative Oxford score (Mean)	Post-operative Oxford score (Mean)	<i>p</i> -value
Classical technique ( <i>n</i> = 17)	23.33	38.93	<0.001
Anatomical technique ( <i>n</i> = 15)	20.71	42.21	<0.001
<i>p</i> -value	0.305	0.040	

scores (Tables 5.3 and 5.4, respectively). The mean postoperative WOMAC score showed no significant difference between the two groups (Table 5.3). More improvement in postoperative Oxford score was seen with the anatomical technique ( $p = 0.04$ ) (Table 5.4).

## 5.4 Discussion

Undercorrection with minor varus was clearly shown to provide better outcomes and longevity than neutral alignment with UKA [26, 27]. Although such an exact degree of optimal correction has not been indicated, computer navigation assisted in reaching appropriate alignment [28]. In general, computer navigation significantly shortens the learning curve for surgeons performing TKA [29, 30]. The early failure phase of UKA was bearing dislocation which our experience found 3 cases in 23 cases with mobile bearing UKA. It was possible that these errors were influenced by the learning curve phenomenon.

Ligament balancing is an essential factor for knee joint stability. The femoro-tibial gap could be measured only at 0° and 90° using the OrthoPilot 3.0 software. Thus, we lacked full information on mid and deep flexion gaps (at 45° and >120°, respectively), which is a current limitation in gap adjustment. For TKA, increasing the posterior tibial slope has been found to lead to deeper flexion [31], whereas the mid flexion gap could be extended by less distal femoral resection,



more femoral flexion, and more tibial resection and slope [32]. For UKA, overall ligament balance adjustments are performed to maintain stability. If the knee is still unstable, an increase in the thickness of the polyethylene liner is required. The alignment, however, must be evaluated after all other adjustments are made and after ensuring that there is no valgus alignment during the fixed-bearing UKA. Our experience of navigated UKA demonstrated that navigation provided interactive simulation that could assess knee kinematics and alignment during surgery and implantation.

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