Unicompartmental Knee Arthroplasty with a Mobile-Bearing Prosthesis: Long-Term Results

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6.1 Introduction

Anteromedial osteoarthritis (OA) of the knee, a distinct pathological condition described by White et al. in 1991 [1], is an ideal indication for unicompartmental knee arthroplasty (UKA). In this condition, the cartilage erosion in the medial compartment begins typically in the anterior half of the tibial plateau, the cartilage being preserved over the posterior third (Fig. 6.1).

There is a corresponding lesion on the distal femoral condyle. The femoral condyle sits within this tibial defect in extension, producing a varus deformity that is corrected on flexing the knee as the preserved cartilage over the posterior condyle of the distal femur rides over the intact cartilage of the posterior tibial plateau. In these cases, the medial collateral ligament is not shortened (Fig. 6.2) and the varus deformity remains correctible in near extension by application of a valgus stress.

The anterior cruciate ligament (ACL) is also usually preserved and the retention of these structures tend to prevent OA from progressing to other compartments of the knee. This pattern of OA accounts for one in three cases of osteoarthritic knees undergoing arthroplasty in some centres.

UKA is a well-accepted treatment option for anteromedial OA as it has many advantages over total knee arthroplasty (TKA). These include less perioperative blood loss, reduced risk of infection, a shorter recovery period, better range of movement and lower morbidity and mortality.

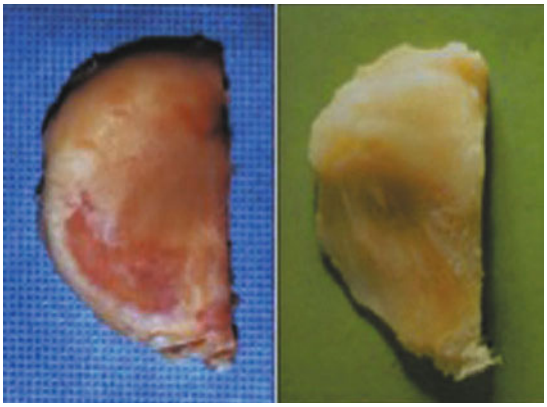

Fig. 6.1 Typical tibial plateau specimen confirming the presence of cartilage erosion in the anterior half

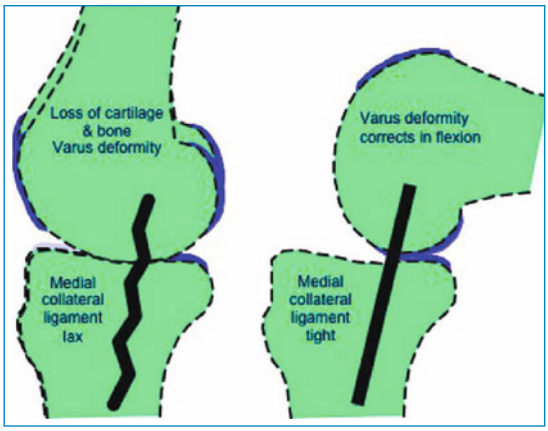

Fig. 6.2 Femoral movement in extension and flexion. The intact posterior tibial cartilage allows the femur to move out of the defect each time the patient flexes the knee

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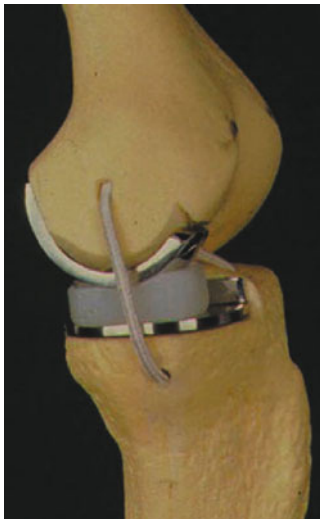

Fig. 6.3 The Oxford Knee

As the cruciate ligaments are preserved, the procedure has the ability to restore knee function to near normal. The knee feels more natural and pain relief is as good or better than following a TKA.

This chapter describes the long-term outcome of patients undergoing UKA, with particular reference to the Oxford Knee (Biomet Europe). Its unique design features are outlined below followed by the methods used to describe the long-term outcome and the outcome data for these patients.

6.2 Implant Design

The Oxford Knee (Fig. 6.3) is the only mobile-bearing fully congruous UKA design approved by the FDA. It has a spherical femoral and a flat tibial component, both made of cobalt chrome. Between the two lies an unconstrained mobile-bearing, the upper surface of which is spherically concave and congruent with the femur while the lower surface is flat and congruent with the tibia. The bearing is congruent in all positions of knee flexion.

Therefore the contact area is large (around 6 cm^2) and the contact pressure is low. This form of articulation, while imposing no constraints upon movements, diminishes polyethylene wear to very low values. Both in vivo and in vitro measurements have confirmed the same.

In vitro measurement of retrieved bearings has shown a mean linear wear rate (combining both articular surfaces, including backside wear) of 0.03 mm per year, and even less (0.01 mm per year) if the knee had been functioning normally without any impingement. Furthermore, the rate of wear is no more rapid when thinner (3.5 mm) rather than thicker components are implanted. The use of the thin polyethylene bearing is advantageous, especially in young and active patients, as the bone stock is preserved.

In vivo measurements by Kendrick et al. [2] used model-based radiostereometric analysis to measure the combined wear of the upper and lower bearing surfaces in 13 Oxford Knees at a mean of 20.9 years (17.2–25.9) postoperatively. The mean linear penetration of the polyethylene bearing was 1.04 mm (0.307–2.15), with a mean annual wear rate of 0.045 mm/year (0.016–0.099).

6.3 Phases in the Development of the Oxford Knee

In phase 1 (1976), the femoral surface was prepared with cutting blocks and saw blades to remove the angular cuts of bone to fit the non-articular surface of the metallic femoral component. This did not, however, allow accurate ligament balancing (flexion/extension gap) and bearing dislocation was an occasional problem.

Phase 2 (1986) saw the introduction of a spherical mill to address this problem. The femoral component was changed to a spherical concave inner surface and the femoral bone surface was thus prepared with a rotating mill around a central spigot. This allowed accurate soft-tissue balancing by incremental 1-mm milling of the distal femoral surface.

The phase 3 design, introduced in 1998, provided new instrumentation and an increased range of components to facilitate the implantation through a short incision (minimally invasive surgical approach). Although the Oxford Knee was the first of its kind, there are currently several other mobile-bearing implants based on a

similar philosophy. The AMC knee (Uniglide) differs from the Ocford Knee with respect to the shape of the femoral component. The radius of the femoral component is constant in the AMC design up to 45° of flexion but decreases towards the posterior position of the condyle, which can affect knee kinematics. This is not the case with the Oxford Knee, in which the radius of curvature is constant throughout. Various studies have demonstrated the restoration of near-normal knee kinematics following Oxford Knee implantation [3, 4] There are very few series reporting the results of the AMC Uniglide implant.

The other category of mobile UKA relates to the LCS mobile-bearing. This device employs a polyradial femoral component articulating with a dished polyethylene bearing that runs back and forth in a track on a metal tibial tray. Again, the polyradial nature of the articulation means that the congruency is lost after 30°; beyond this flexion the device acts as a fixed-bearing implant. More damaging, however, is the conflict between the bearing movement and the track; indeed, many devices jammed and failed. The mobile iteration of the LCS UKA is therefore no longer used.

6.4 Long-Term Outcome

Ideally, the long-term outcome should reflect the results and outcome of all the patients who have undergone a particular procedure for the entire lifespan of that implant; that is, the endpoint should be either that the patient has died or that the implant has been revised. This approach is, obviously, not realistic; instead, the next best assessment is a prediction of the real long-term outcome. This is best achieved by survivorship analysis, which is widely used in reporting the results of joint arthroplasty. The method allows the failure rate of an implant to be predicted based on the results of a series of operations that may have different lengths of follow-up but are assumed, for the purposes of the analysis, to have all been performed at the same time. The method calculates a cumulative survival rate from the failures occurring at differing time periods. It is commonly used to determine the results obtained with in a population with a single series of prosthesis or to study and compare the results from a larger populations in which different prostheses were used, as in National Joint Registries. In most survivorship studies, all-cause revision is reported as the primary end-point. This can be further modified to differentiate revisions performed for various reasons, for example, aseptic loosening (as is commom in the American literature), from failures secondary to infection, type of revision implant used, etc. Survival analysis may be performed using either the life table method or the Kaplan-Meier method.

Whichever method is employed, there are a number of features that must be understood about the reported data. Survival figures are cumulative, which allows a prediction of the expected failure rate in the long term, reducing the need for a large number of prostheses to have reached the long-term follow-up end-point. However, the number at risk at each time point must be known since if the number reduces to less than 15 it becomes difficult to interpret the data. Loss to follow-up is also important, and studies should present worst- as well as best-case scenarios.

The long term results of mobile-bearing UKA are available from three main sources: cohort studies, prospective trials and arthroplasty registries (regional or national).

6.5 Cohort Studies

Khanna and Levy outlined and compared 17 published clinical studies, comprising 2,847 patients. Follow-up ranged from 2 to 22 years during which there were 77 (2.7%) device-related failures [5]. The survivorship ranged from 84.0% (at 10 years) to 100% (at 10 years), with the majority of studies quoting survivorship > 94%.

Cohort studies are usually based around the observed results of cases treated by a single surgeon or a small group of surgeons (usually from a single unit). Their advantage is that groups of patients are followed in detail and with often near-complete follow-up. The indications for surgery, operative technique and postoperative

Table 6.1 Summary of 10-year survival studies

Year	Author	Phase	Number	Mean age (years)	Mean follow-up (range)	Survival % (95% CI)
1998	Murray et al. [6]	1 and 2	144	71 (35–91)	7.6 (6–14)	97 (93–100)
1999	Kumar and Fiddian [12]	2	100	71	5.6 (1–11)	85 (78–92)
2001	Svard and Price [10]	1 and 2	124	70 (51–86)	12.5 (10.1–15.6)	95
2002	Emerson et al. [14]	2	50	64	6.8 (2–13)	92
2004	Keys et al. [9]	2	40	68 (40–80)	7.5 (6–10)	100
2004	Rajasekhar et al. [8]	2	135	72 (53–88)	5.8 (2–12)	94 (84–97)
2006	Vorlat et al. [13]	2	141	66 (46–89)	5.5 (1–10)	82 (SE 6.9)
2009	Mercier et al. [11]	3	43	69 (47–86)	14.9	75
2011	Pandit et al. [7]	3	1000	66 (32–87)	5.6 (1–11)	96

rehabilitation tend to be standardised. However the total number of patients is often small and may include non-continuous series, with exclusions. Additionally, these studies are open to bias as they are often reported by the designer(s) or the enthusiasts such that the results may not be representative of the implant outcome in general orthopedic practice. Nonetheless, these cohort studies provide important information as to the success or failure of the intervention and can usually be treated as the best-case scenarios.

A 10-year follow-up of the Oxford Knee was reported in nine studies, with a wide range in the reported survival (Table 6.1). In six of the nine studies cumulative survival at ten years was 94% or greater. In three series, however, the cumulative survival was 85% or less. The designer series by Murray et al. [6] for phases 1 and 2 of the Oxford Knee reported a 10-year cumulative worst-case survival rate of 97% (confidence interval (CI): 93–100%). In that series 44 knees were at risk at 10 years and no failures were due to polythene wear or aseptic loosening of the tibial component. Pandit et al. [7] reported the designer series of the phase 3 Oxford Knee, with 1000 knees; the survivorship at 10 years was 96% (number at risk at 10 years: 121) (Fig. 6.4).

Rajasekhar et al. [8] obtained similar results, with a 94% cumulative survival of phase 2 Oxford Knees at 10 years while Keyes et al. [9] reported excellent results with their first 40 phase 3 Oxford knees. The latter study had an average follow-up of 7.5 years, with a survivorship at 10 years of 100%, without any patients lost to follow-up. In another independent series of phase 1 and 2 knees, Svard and Price [10] showed a cumulative survival of 95% for 124 patients at 10 years.

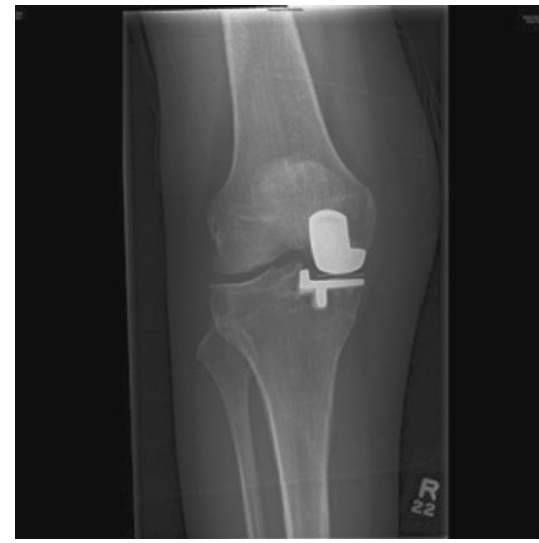

Fig. 6.4 X-ray showing a phase 3 Oxford Knee in situ at 12 years

Mercier et al. [11] reported an overall survival of 74.7%. They specifically drew attention to their broad selection criteria, including ACL-deficient knees and inflammatory arthropathy, neither of which are ideal indications for UKA. If these cases are excluded from this series, the 10-year survival is >85%. In a similar fashion, Kumar and Fiddian reported a 10-year survival of 85% (CI: 78–92%) at a mean follow-up of 5.6 years [12]. They also drew attention to inflam-

Table 6.2 Summary of 20-year survival studies

Year	Author	Phase	Number	Mean age (years)	Survival (95% CI)	Survival (95% CI)
2010	Price and Svard [16]	1, 2 and 3	683	69.7	92.1 (+ 33.2)	97 (93–100)
2010	Barrington and Emerson [17]	2	54	64	94 (-)	85 (78–92)

matory arthropathy as an inappropriate indication for patient selection. Vorlat et al. showed the effect of previous high tibial osteotomy (HTO) on the outcome of Oxford Knee [13]. The overall cumulative survival at 10 years in their series was 82%; however, four of the failures were in eight patients who had previously undergone HTO.

In 2002 Emerson et al., compared 51 fixed-bearing UKA with 50 mobile-bearing UKA. Survivorship analysis based on component loosening and revision showed a 93% survival for the fixed-bearing UKA and a 99% survival for the mobile-bearing UKA (Oxford knee) at 11 years. The latter implants had no tibial component failure, in contrast to the fixed-bearing implant (six of the eight failed UKA were due to tibial component failure). This study cohort was part of a study in which the Oxford knee was introduced into the USA [14]. The surgical technique used in that study included subtle release of the medial collateral ligament (MCL), which could have predisposed to the failures in the mobile-bearing group secondary to progression of arthritis in the retained lateral compartment (n = 4).

These last four papers show the importance of indications and technique on outcome and that extending the indications outside the recommended ones has an adverse effect on the results.

6.6 Twenty-Year Studies

Price and Svard reported the continuation of their 10-year study, which was also reported at 15 years (Table 6.2) [15, 16]. Their report included all cases in which there was no loss to follow-up. Among the 683 consecutive knees that were assessed the overall cumulative survival was 92% at 20 years. The most common cause for revision was the progression of arthritis in the retained lateral compartment although over the 20-year period this occurred in only ten patients (1.5%). This study also reinforces the importance of adhering to the present indication of excluding patients with previous HTO or ACL deficiency, as the inclusion of these cases reduced survival to 71%. Another interesting feature of this 20-year series is the number of relatively few failures that occurred in the second decade. There is a consistent trend across all the series in that infection and dislocation tended to present as early complication after UKA, with lateral compartment arthritis and loosening accounting for the majority of mid-term failures. None of the failures in the second decade, as reported by Price and Svard, were due to polyethylene wear, suggesting that the design features of reducing contact stress successfully prevent catastrophic wear for at least 20 years. Barrington and Emerson also reported 20-year results with the Oxford Knee (Table 6.2) [17], with a survivorship of 94% and no revisions for bearing dislocation, tibial subsidence or polyethylene wear. They also reported excellent functional scores: the mean American Knee Society Score improved from 47 (preoperative) to 94 (postoperative).

In assessing the few available studies that reported on long-term clinical outcome, it is clear that no consistent clinical outcome assessment tools were used, making generalised interpretation rather difficult. The common theme, however, seems to be that clinical scores improve significantly from the postoperative period within the first year and remain almost unchanged over the subsequent follow-up period. The long-term data of Price and Svard and of Pandit et al. suggest that the significant increase in clinical scores does not decrease with time. The patients' function is as good 10 years postoperatively as it is at one year.

6.7 Randomised Controlled Trials

Prospective randomised controlled trials of a prosthesis or surgical technique allow many of the flaws of cohort studies to be overcome, but they are much less common and more difficult to conduct. This is, in general, a reflection of the cost and complexity of the organisation and execution of such studies. When available, however, they provide better qualitative data than cohort studies, although they have yet to include cumulative revision rates at 10 years from a randomised controlled trial for a mobile-bearing UKA.

6.8 Joint Registries

The primary function of national joint registries is to assess the success of treatment in large population-based cohorts. The data provided represent clinical practice without the inherent bias in cohort studies and can be used to compare the outcome of implant designs. Consequently, registers have always taken revision as the marker of failure and cumulative revision rate as the comparator between implants. While revision is a definite end point and therefore can be easily measured, there are some difficulties with the interpretation of revision rates. Unfortunately, arthroplasty registers collect limited data and exert no control over patient selection, surgical expertise and indications for revision.

Analysis of the data from every national register shows that the failure rate of UKA is between four and six times higher than that of TKA. This suggests either a higher proportion of unhappy patients or other factors, such as ease of revision, acting to distort the results. The evidence as to the cause of this higher failure rate is found in the New Zealand Joint Register. The New Zealand Joint Registry publishes not only the revision rates but also the equally relevant clinical outcomes (Oxford Knee Scores), allowing comparison of these two measurements. UKA patients consistently had a better knee score than TKA patients; however, the revision rate of the former was nearly three times higher than that of the latter because the sensitivity of the revision rate to clinical failure differs for the two implant types. For example, of knees with a very poor outcome (Oxford Knee Score < 20), only about 12% of TKAs were revised compared with about 63% of UKAs with similar scores. This confirms the limitations of joint registries. While they do provide information on the various types of implants, their usage and survival, the data should be interpreted with caution. There are many factors that contribute to the success (or failure) of an implant; of course, registries should not be used to compare a unicompartmental implant with a total knee replacement implant. Another interesting (obvious but easily ignored) fact about an implant is that its success is decided by the surgeon who implants it, as demonstrated by the Swedish Registry. In 1995, the registry data suggested that Oxford Knee was not performing well in Sweden; therefore, the registry wrote to all surgeons in Sweden advising them to stop the procedure. However, surgeons who always had good results with the Oxford Knee continued to use it. The 2005 data from the same registry showed Oxford Knee to be the best performing UKA, presumably in great part due to instructional courses and the effect of education. This shows that the registries should be used with caution when comparing UKAs with one another and should not be used to predict how well a particular UKA will perform over time.

Registries are, nonetheless, helpful in identifying individual surgeons who are not performing as well as their colleagues. The National Joint Registry of England and Wales provides funnel plots for individual surgeons; those with failure rates outside two standard deviations of the average are identified and contacted by the registry (in confidence) to help them (and, in turn, their patients) by highlighting the high failure rates. These surgeons can be further trained or be urged to stop UKA surgery altogether.

Three national registries have reported specific data for the Oxford Knee at approximately the 10-year time point. Other national registries (for example the New Zealand and the Norwegian registries) do not report separate outcomes for fixed- vs. mobile-bearing UKA and in some cases do not differentiate between medial and

Table 6.3 Breakdown of causes of revision and its incidence as percentage at 10 and 20 years

	10-year studies (4116 patients)	20-year studies (736 patients)
Bearing	0.9	0.4
Bearing dislocation	0.7	0.3
Bearing fracture	0.1	0.0
Bearing impingement	0.1	0.1
Wear	0.4	0.0
Polyethylene wear with major osteolysis	0.0	0.0
Loosening (total)	1.1	1.4
Loosening (not specified)	0.2	0.1
Loosening (both)	0.1	0.3
Femoral loosening	0.2	1.0
Tibial loosening	0.6	0.0
Pain	0.3	0.4
Progression	1.1	2.2
Patellofemoral joint progression	0.0	0.0
Lateral progression	1.1	2.2
Infection	0.4	0.7
Prosthesis fracture	0.1	0.0
ACL rupture	0.2	0.0
Plateau fracture	0.1	0.0
Recurrent haemarthrosis	0.1	0.0
Instability	0.1	0.0
Total revisions	4.6	5.0

lateral UKA. The England and Wales National Joint Registry presently reports revision rates for specific implants but results are only available for the last three years. Therefore, these registries have not been included in this analysis. In the 2009 Annual Report of the Swedish Knee Arthroplasty Register, the cumulative 8-year survival for the Oxford Knee was >91% [18]. The Australian Orthopedic Association Joint Registry data from 2009 [19] reported a cumulative survival of 87.1% at 8 years while the Finnish Arthroplasty Register reported a 10-year survival of 81% for the Oxford Knee, slightly better than for the fixed-bearing device (79%, Miller Galante). There is no further detailed information in these reports for mobile-bearing UKA.

6.9 Reasons for Revision

As stated earlier, the revision rates are low in various large cohort studies and the majority of the revisions tend to occur early. The main reasons for failure of a TKA in the second decade tend to be wear and / or component loosening. Unlike TKA, there are very few revisions in the second decade after implantation of the Oxford Knee. The reasons for revision are summarised in Table 6.3. Not only is the incidence very low but in the majority of cases the UKA can be revised to a primary TKA without the need for augments or stems.

The excellent survival, low morbidity and mortality along with the ease of revision to primary TKA make UKA an ideal treatment option in patients with anteromedial osteoarthritis.

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