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Introduction and Historical Overview

Osteoarthritis of the knee is one of the most common causes of painful loss of mobility in middle-aged and elderly people in many populations and is the main indication for knee replacement surgery. From the early days of arthroplasty, it was recognised that arthritis was often limited to the medial (or lateral) compartment of the knee and, in the pioneering operation of MacIntosh [1], metal spacers could be used in one compartment or both. Gradually, however, as the advantages of bicompartmental arthroplasty were appreciated, unicompartmental (or partial) replacement was less and less practised, and in some countries almost disappeared. With the introduction of tricompartmental replacement, a large body of surgical opinion concluded that osteoarthritis of the knee was a disease of the whole joint (like osteoarthritis of the hip) and that common sense required the replacement of all the articular surfaces to provide long-term relief of symptoms.

The attention of designers and manufacturers focused on the improvement of implants and instruments for total replacement, and the gap between the survival rates of unicompartmental knee arthroplasty (UKA) and total knee arthroplasty (TKA) widened, reinforcing the prevailing opinion of their fundamental merits.

Popular neglect of the unicompartmental alternative is reflected in a lack of innovation. The St Georg (1969) is still in use today, and most designs developed since are similar to that. Until recently, the components were implanted largely 'by eye', as in the early days of total replacement.

A further consequence of the success of TKA was loss of interest in the natural history and pathological anatomy of the osteoarthritic knee. Since total replacement is equally applicable, and almost equally successful, over the whole range of manifestations of that disease, there was no longer much point in its further analysis. However, the longitudinal studies by Ahlback [2] had already suggested that unicompartmental osteoarthritis does not inevitably spread to other parts of the knee. In addition, numerous post-mortem descriptions published in the 1970s and 1980s had revealed the almost universal presence of cartilage lesions in some parts of the joint in middle-aged and elderly people, implying that their presence is consistent with normal knee function. These observations challenge the common-sense conclusion that replacement of all the articular surfaces is a necessary requirement for a clinically successful arthroplasty.

UKA versus TKA

A few surgeons have been able to report clinical results and cumulative survival rates after UKA to match those of total replacement, but the general opinion, led by National Registers, is that the failure rate of UKA is not only much higher than TKA; but also is unacceptably high. If the failure rate is so high, why should surgeons bother with UKA? It may, of course, offend one's sense of economy to replace more of a damaged joint than is necessary, but there are more practical reasons as well. The function following UKA tends to be better than following TKA; successful UKA is even more effective than successful TKA. Many surgeons who have performed both procedures have found that the range of flexion is greater and gait is more nearly normal, particularly with demanding activities like stair descent, because the biomechanics of the knee are more completely restored [3, 4].

However, it is on the grounds of safety, with reduced morbidity and mortality, that unicompartmental replacement most strongly recommends itself. To examine rare events such as mortality, large data sets are necessary. As unicompartmental replacement tends to be used more in younger active patients than total knee replacement, it is essential that patients are carefully matched so as to achieve a fair comparision. Based on data from the National Joint Register of England and Wales (NJR) and other large data sets, 25,000 UKA were matched with 75,000 TKA [5]. While the revision rate of UKA was 2.4 times higher at eight years than TKA, there were many advantages of UKA. The hospital stay was shorter and readmission within one year was less. The incidence of major medical complications such as myocardial infarction, stroke, thromboembolism and deep infection was about half and the death rate was lower. During the first thirty days post-operation, the death rate was about one quarter, and even out to eight years it was 13% less. If 100 patients had a unicompartmental knee rather than a total, over an eight-year period, one life would be saved at the expense of three revisions. On the basis of these results, Cobb concluded that UKA is "unequivocally safer" than TKA [6]. Even taking into account the higher revision rate, UKA is still more cost effective than the TKA option [7, 8]. A large study by Willis-Owen *et al*. showed nearly 50% of knees presenting with end-stage arthritis are suitable for a UKA and UKA offers a substantial cost saving over TKA (£1761 per knee) [9].

Revision tends to be easier after UKA than TKA as it usually involves a simple conversion to a TKA. The results of revisions of UKA are better than those of revised TKAs and nearly as good as those of primary TKA [8]. As a result, the threshold for revision of UKA is lower than that of TKA. Following a UKA, about 60% of patients with very poor results have revisions whereas only about 10% of TKA with similarly poor results have revisions [10]. Therefore, even though UKA tend to have fewer poor results than TKA, they have a higher revision rate. If the possibility to rectify a problem following a joint replacement can be considered to be an advantage, the higher revision rate of UKA, which is a manifestation of its ease of revision, should not be considered to be a disadvantage.

Unicompartmental implant design

The first 'modern' designs, the St Georg (1969) and the Marmor (1972), had poly-centric metal femoral condyles articulating on flat (or nearly flat) polyethylene tibial components, both cemented to the bones [11, 12] (Fig. 1.1). The stated principles of Marmor's design were to reproduce as accurately as possible the polycentric form of the natural femoral condyles; and to avoid constraint of the articulation by employing a non-conforming tibial plateau [13]. Most of the models introduced since were designed on the same principles.
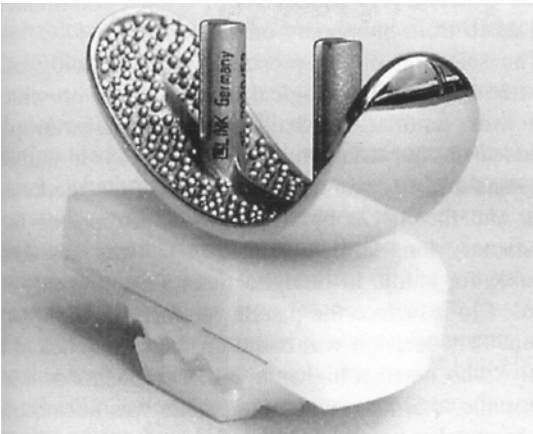

Figure 1.1 St Georg unicompartmental prosthesis.

Initially, problems were caused by loosening following distortion of the thinnest polyethylene components (6 mm thick), which were abandoned in favour of thicker ones [14]. The persisting problem of deformation of the all-polyethylene component led to the use of metal-backed tibial implants, but this, in turn, resulted in diminished thickness of polyethylene and sometimes further problems with wear [15]. However, the fundamental problem remained. A round femoral component makes contact with a flat tibial component on a very small contact area, with high contact stresses, so that problems of wear and deformation were inevitable [16, 17]. Using a more conforming tibial component introduces constraints which may not be compatible with ligament function (see Chapter 3).

The Oxford Knee

Phase 1

In 1974, two of the authors (JWG and JJOC) introduced congruous mobile bearings for knee prostheses [18]. The first 'Oxford Knee' had a metal femoral component with a spherical articular surface, a metal tibial component which was flat, and a polyethylene mobile bearing, spherically concave above and flat below, interposed between them (Fig. 1.2). The device was fully congruent at both interfaces throughout the range of movement (to minimise polyethylene wear) and fully unconstrained (to allow unrestricted movements and minimise the risk of loosening). These features of the Oxford Knee have remained unchanged to the present day.

Figure 1.2 The Oxford Knee (Phase 1) (1978).

At first, the implant was used bicompartmentally, as a total joint replacement, with two sets of components inserted one medially and one laterally. The non-articular surface of the femoral component of the original design (Phase 1) had three inclined facets and was fitted to the femur by making three saw-cuts as shown in Figure 1.3. Many surgeons found it difficult to locate the femoral component accurately in relation to the ligaments and, therefore to match the extension gap to the flexion gap.
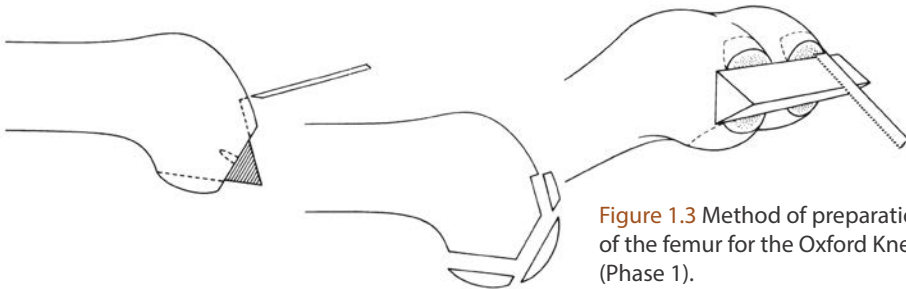

Figure 1.3 Method of preparation of the femur for the Oxford Knee (Phase 1).

It became apparent that good results were only achieved if the ACL was intact [19]. Another observation was made, that if the ACL was intact, then the arthritis tended to be confined to the anteromedial part of the tibia and the distal part of the medial femoral condyle. In these cases, all ligaments were functionally normal. This disease was called Anteromedial OA (AMOA) [20]. On the basis of these two observations, in 1982 the device began to be used unicompartmentally and the primary indication was AMOA.

Phase 2

In 1987, the Phase 2 implant was introduced specifically for unicompartmental arthroplasty [21]. The non-articular surfaces of the femoral component had a flat posterior facet and a spherically concave inferior facet (Fig. 1.4). The posterior femoral condyle was prepared by a saw-cut and its inferior facet was milled by a