Early mechanical complications of a multidirectional mobile-bearing total knee replacement

Between April 2004 and July 2007, we performed 241 primary total knee replacements in 204 patients using the e.motion posterior cruciate-retaining, multidirectional mobile-bearing prosthesis. Of these, 100 were carried out using an image-free navigation system, and the remaining 141 with the conventional technique. We conducted a retrospective study from the prospectively collected data of these patients to assess the early results of this new mobile-bearing design.

At a mean follow-up of 49 months (32 to 71), 18 knees (7.5%) had mechanical complications of which 13 required revision. Three of these had a peri-prosthetic fracture, and were removed from the study. The indication for revision in the remaining ten was loosening of the femoral component in two, tibiofemoral dislocation in three, disassociation of the polyethylene liner in four, and a broken polyethylene liner in one. There were eight further mechanically unstable knees which presented with recurrent disassociation of the polyethylene liner. There was no significant difference in the incidence of mechanical instability between the navigation-assisted procedures (8 of 99, 8.1%) and the conventionally implanted knees (10 of 139, 7.2%).

In our view, the relatively high rate of mechanical complications and revision within 30 months precludes the further use of new design of knee replacement.

Total knee replacement (TKR) with mobile-bearing polyethylene liners was first introduced in the 1970s because of the potential advantages of better congruity between the articular surfaces, improved range of movement, less wear and higher tolerance of minor surgical technical errors because of its self-aligning nature.1 Studies using the low contact stress meniscal-bearing and rotating-platform knees have reported a longer survival compared with that of fixed-bearing designs.2-6

Supportive biomechanical studies have shown improved distribution of stress for existing mobile-bearing designs. Moreover, a reduced amount of polyethylene wear in these designs has been reported in some clinical studies.7,11 However, most studies comparing mobile- and fixed-bearing TKRs do not report a significant difference between these two designs in terms of the clinical outcome and the range of movement.12-18

Furthermore, the major clinical concern of the mobile-bearing knee is its inherent instability, and a rate of dislocation or disassociation of the liner as high as 9.3% has been reported.19

In recent years, prostheses with newer mobile-bearing designs have been introduced. The e.motion knee (Aesculap, Tuttingen, Germany) was designed as a floating platform prosthesis with large contact areas. The polyethylene insert can glide and rotate multidirectionally on the tibial tray, while a protruding hooked spine on the tray controls and prevents dislocation of the bearing (Fig. 1). A previous biomechanical study indicated that there was good congruity between the femoral component and the polyethylene liner as well as good stress distribution during flexion.7 A randomised study on the early clinical outcome of the new device showed that it was at least as effective as a fixed-bearing design and even achieved a higher range of movement (mean 143°), although this was not statistically significant.20

We started using this TKR in April 2004 in an attempt to achieve better movement, with reduced polyethylene wear and prolonged longevity. Our aim in this study was to assess the clinical outcome and survival of the e.motion mobile-bearing TKR in knees with a minimum follow-up of 30 months.

Patients and Methods

Between April 2004 and July 2007, we performed 241 primary TKRs in 204 patients
measurement of limb alignment and respective gaps was performed using the e.motion cruciate-retaining mobile-bearing prosthesis. During this period, it was used for all primary TKRs, except for knees with deformities exceeding 20° varus and 10° valgus, previous major trauma or instability. There were 160 women (187 knees) and 44 men (54 knees) with a mean age of 70.1 years (51 to 85). There were 125 right and 116 left knees. The pre-operative diagnosis was osteoarthritis in 234 knees and rheumatoid arthritis in the remaining seven. The mean height of the patients was 154.3 cm (135 to 174) and the mean weight 65.1 kg (38 to 97). Our study was approved by the Institutional Review Board of our hospital. All the information including the pre-operative clinical status and the outcome was collected prospectively using predesigned datasheets and maintained by an independent investigator (CWC).

Two experienced knee surgeons (KAL, CYY) performed all the operations through a medial parapatellar approach. Successful implantation of this prosthesis requires an intact posterior cruciate ligament as well as stable collateral ligaments, and special attention is required to match the flexion and extension gap. An image-free navigation system and associated software (OrthoPilot version 4.0; Aesculap) providing real-time measurement of limb alignment and respective gaps was used for balancing the medial and lateral compartments with both bony cuts and soft-tissue preparation. When the navigation system was not available, the procedure was performed using conventional gap-balancing techniques consisting of initial proximal tibial resection perpendicular to the longitudinal axis of the lower limb, followed by a stepwise release of soft tissues to achieve ligamentous balance in flexion and extension. The decision to use navigation was based on the surgeon’s preference and the patient’s willingness; 100 TKRs were performed using the navigation system and 141 with conventional jigs. All the implants were cemented and the patellae were resurfaced routinely.

All the patients followed the same rehabilitation protocol, including continuous passive movement, physiotherapy with active strengthening exercises for the quadriceps and hamstrings from the second post-operative day, and walking bearing full weight as soon as comfort permitted. At discharge, all the patients had achieved 90° of flexion of the knee and could walk with the aid of a walker.

Clinical and radiological assessments were undertaken at six weeks, three months, and one, two, and five years after surgery. Radiological evaluation included weight-bearing anteroposterior, lateral and skyline views of the patellofemoral joint. The alignment and position of the prosthesis were analysed using the Knee Society Roentgenographic Evaluation System.

The prosthesis-related complications included loosening of the components, broken inserts, dislocation and symptomatic instability. Subtle symptoms such as clicking with movement or a feeling of instability were not included.

**Results**

The mean follow-up was 49 months (32 to 71). The OKS significantly improved from a mean of 39.5 (21.0 to 58.0) points pre-operatively to 19.5 (12.0 to 32.0) and 17.7 (15.0 to 29.0) points at six months and two years after surgery, respectively (t-test, p < 0.001). The mean range of flexion significantly improved from 99.7° (50.0° to 135.0°) pre-operatively to 108.7° (65.0° to 145.0°) and 112.0° (90.0° to 145.0°) at six months and two years after surgery, respectively (t-test, p < 0.001).

There were no major problems with wound healing or neurovascular complications. However, 13 knees (5.4%) had required re-operation, in three for a peri-prosthetic femoral fracture. These three were therefore excluded from our study. In the remaining ten knees the reasons for revision included loosening of the femoral component in two (Fig. 2), irreducible dislocation of the polyethylene liner in three (Fig. 3), disassociation of the liner in four (Fig. 4) and a broken polyethylene liner in one (Fig. 5).

Of the revision procedures, nine were performed using a posterior stabilised fixed-bearing prosthesis (five) or a more constrained design (four). There were mechanical complications in eight (3.4%) further knees, presenting as recurrent reducible disassociation of the polyethylene liner. This was subjectively identified by the patients as ‘giving way’ or locking during activities of daily living. Revision surgery was advised, but remained pending because of the patients’ hesitation in all eight cases.

The original diagnosis of these 18 knees with complications was osteoarthritis. The details of these patients are...
given in Table I. These mechanical complications first occurred at a mean of 8.4 months (2.0 to 23.0) after the initial procedure.

Eight of these mechanical failures occurred in the navigation-assisted TKRs (8 of 99, 8.1%) and ten in the TKRs implanted conventionally (10 of 139, 7.2%). With regard to the post-operative mechanical axes in the frontal plane, only two were outliers (>3° valgus or varus).

**Discussion**
Mobile-bearing implants can be classified as cruciate ligament-retaining, posterior stabilised, mobile meniscal, rotating platform and multidirectional platform, based on the mobility and constraint of the design in the rotational, mediolateral and anteroposterior direction. In an international long-term study of the survivorship of mobile-bearing TKRs, the bearing-related issues of instability, subluxation, dislocation and wear were reported to account for 2.3% of 4743 knees replaced by 27 surgeons. In theory, the newer 'multidirectional platform' has better mobility than the previous rotating-platform design in the mediolateral or anteroposterior direction. Moreover, there are characteristic grooves on both sides of the e.motion femoral component and its articulating polyethylene insert. The improved conformity results in linear flexion-extension friction instead of multidirectional friction, making it more resistant to wear. In a biomechanical analysis, the contact between the femoral-bearing articulations during flexion of 0° to 90° was found to be better in the e.motion prosthesis than in the other three designs.
investigated. In one study it was concluded that this new prosthesis was at least as effective as the established fixed-bearing implant, although more revisions (3 of 30, 10%; 2 patellar problems, 1 anterior instability) were seen with the mobile-bearing knees.

In our series, a mean flexion of 112° was achieved at two years after surgery, which was similar to that obtained in the study of Geiger et al. Although high flexion isfavoured by our population, the biomechanics of a high-flexion mobile-bearing design are not favourable. Banks et al. studied the movement of the knee during maximum flexion using fluoroscopy and found greater maximum flexion angles and a more posterior femoral position in both fixed-posterior-stabilised and cruciate-retaining fixed-flexion angles and a more posterior femoral position in both fixed-posterior-stabilised and cruciate-retaining fixed-bearing TKRs as compared with mobile-bearing TKRs. Catani et al. studied the differences between mobile- and fixed-bearing TKRs in patients who were made to climb and descend stairs. They noted that abnormal compensatory mechanisms occurred more often in the mobile-bearing design. Garling et al. also found greater rotation of the femoral component instead of rotation of the bearing during step-up movement.

In our study, all the operations were performed either with the assistance of a navigation system or with conventional jigs by experienced surgeons. The early rates of mechanical complications of different surgical methods were similar (8.1% with the navigated system and 7.2% with the conventional technique). Furthermore, the most unstable episodes were sporadically distributed beyond the initial phase (the first 25 to 30 cases), indicating that the learning curve was not a critical factor for the causation of mechanical complications.

For a mobile-bearing TKR to be successful the appropriate selection of patients is essential. We therefore excluded all patients with severe deformities, previous trauma and instability.

Although mobile-bearing designs have a better tolerance to minor technical errors in comparison with the fixed-bearing implants, certain factors such as a mal-aligned component or a gap mismatch may endanger the stability of the imbalance-sensitive prosthesis. Moreover, a malrotated femoral component may not only potentiate lateral dislocation of the patella, but also risk lateral disassociation during flexion. In the 18 knees with complications, two had axial malalignment. We also noted that one femoral component was internally rotated and two others externally rotated in knees which had a disassociation of the bearing.

Early loosening of the femoral component has been reported only rarely in the literature, but in our series there were two cases of loosening of the femoral component at a mean of 19 months. The high conformity of the characteristic two grooves on the femoral component and the insert allows only for flexion-extension at the femoral articulation. Furthermore, the floating platform mainly rotates between the bearing and the tibial tray instead of at the femoral component-bearing articulation. We postulate that this may be the reason for the loosening of the femoral component and instability between the femoral component and the bearing. In this design, the insert is allowed to rotate 15° internally as well as externally without overhang if the bearing glides into the anterior constraint. However, no rotation is allowed before there is overhang after the bearing glides into the posterior constraint. Once the soft tissues heal after surgery, rotation may be further limited, and this may lead to transfer of the rotational load to the prosthesis-bone interface or dislocation or disassociation of the bearing.
To our knowledge this is the largest series of second-generation mobile-bearing designs with clinical instability to be reported. Although subtle symptoms such as subjective instability or clicking with movement were not included in our study, several recent reports using the mobile-bearing design have addressed these issues. In a multicentre, randomised controlled trial using a similar mobile-bearing total meniscal knee system (Biomer Merck, Bridgend, United Kingdom), it was noted that the performance was worse at three years compared with the results obtained at one year. Also, the prevalence of symptoms related to instability was 7.5%, which included noise (clicking), a subjective sensation of instability, and decreasing side preference.

In summary, we observed a high rate of mechanical failure (7.6%) during the early post-operative period after the introduction of the mobile-bearing TKR. We therefore ceased using this design.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References