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Case report

Twenty-year survivorship of a cemented mobile bearing Total Knee Arthroplasty

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ABSTRACT

Background: Increasing numbers of Total Knee Arthroplasty (TKA) operations are carried out worldwide each year. This brings with it an ever-increasing revision burden and it is therefore important to appreciate both the functional outcome and survivorship of established arthroplasties when considering new designs. We aim to evaluate the long-term survivorship of a fully cemented mobile bearing Total Knee Arthroplasty.
Methods: This study prospectively analyses the 20-year survivorship of a cohort of 487 consecutive patients who underwent cemented TKA under the care of a single surgeon using the Low Contact Stress (LCS) rotating platform (RP) implant. These patients were followed up prospectively with patient reported and functional outcomes recorded at regular intervals postoperatively.
Results: Five hundred and forty-two consecutive primary TKAs were carried out in 487 patients. A total of 139 knees (25.6%) were reviewed at 20 years post-operation. Overall cumulative survivorship, using revision for any reason as primary endpoint, was 98.0%. Mean Knee Society Scores for the patient cohort were 87.3 (Clinical score) and 52.5 (Functional score). Eleven (2.0%) were revised within 20 years — two for aseptic loosening, two for unexplained pain, five secondary patellar resurfacings for anterior knee pain, one for late infection and one liner exchange following spin-out.
Conclusion: This series demonstrates excellent survivorship and satisfactory outcome of a cemented mobile bearing TKA at 20 years.

1. Background

Total Knee Arthroplasty (TKA) is one of the most commonly performed orthopaedic operations worldwide, with over 700,000 primary TKAs carried out in the United States of America (U.S.A.) alone in 2013 [1]. This figure is projected to increase to almost 3.5 million primary TKAs in the U.S.A. by the year 2030 [2]. Increasing patient life expectancy [3], together with accelerated osteoarthritic change (and therefore earlier primary surgery) due to rising levels of obesity [4], necessitates the use of implants for TKA with excellent long-term reliability.

Mobile bearing total knee implants were developed in the late 1970s with a view to minimising the wear and loosening seen in implants at that time. In contrast to a fixed bearing knee, the polyethylene bearing is able to move over the tibial tray. The

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theoretical benefits of a mobile bearing implant have been widely discussed in the published literature [5,6]. Bearing mobility allows an increase in polyethylene liner conformity, with a theoretical reduction in liner wear [5], and reduced implant bone interface stress, again with a theoretical reduced rate of aseptic loosening [5–7].

In vitro studies have shown almost a four-fold reduction in wear rate for rotating platform (RP) mobile bearing prostheses when compared with fixed bearing prostheses. It has been postulated that this effect is due to redistribution of multidirectional motion from the femoral-insert to the tray-insert articulating surface. This decoupling is thought to lead to reduced rotation at the femoral-insert articulation, with unidirectional movement along the orientation of polyethylene fibres in the liner and, ultimately, lower wear rates [8,9]. Despite these theoretical benefits, significant advantages in long-term outcomes have not yet been documented in the literature.

In the United Kingdom (UK) the 'Getting It Right First Time' (GIRFT) report advocated cemented fixation as the gold standard for implant fixation [10]. It is generally agreed that cemented fixation provides excellent long-term survivorship with good functional outcome [11,12]. In addition, cemented implants tend to be more cost-effective than cementless equivalents [13].

The purpose of this study is to evaluate clinical outcomes and survivorship of a single centre patient cohort undergoing cemented mobile bearing TKA with a minimum 20-year follow-up.

2. Methods

This study utilises a prospective, non-randomised observational approach to assess survival and revision rates of the fully cemented Low Contact Stress (LCS) Universal non-posterior stabilised RP TKA (DePuy Orthopaedics International, Leeds, UK) implants. From November 1993 to March 1996, 542 fully cemented TKAs were carried out on 487 patients at a regional orthopaedic centre, under the care of the senior author working with three arthroplasty fellows. Irrespective of deformity, the only other knee used during this time period was a number of cementless knees of the same implant. In total, 55 patients underwent bilateral surgery. Of these, 20 (40 knees) were staged and 35 (70 knees) were simultaneous. Twenty-three patients (24 knees [4.4%]) underwent patellar resurfacing at the time of primary surgery. The use of patient details included in the research database was ethically approved by a regional Research Ethics Committee (Reference Number 13/NI/0078).

In varus deformity, a medial Insall approach was used [14]. At that time, and in contrast to now [15], the insertion of the deep medial collateral ligament (MCL) into the proximal tibia was released using a Cobb elevator. In fixed flexion this was combined with stripping of the posterior capsule and resection of additional distal femur to achieve full extension. Again, in contrast to now [15], in patients with valgus deformity, a lateral approach was performed, as described by Keblish, with release of the lateral collateral ligament, popliteus and the lateral head of gastrocnemius from their insertions onto the distal femur in severe deformity. A tourniquet was used in all cases, with inflation prior to skin incision and release immediately after deep closure.

As part of routine follow-up, patients were reviewed with outcome scores and radiological assessment at three, 12, 60, 120 and 240 months post-primary surgery. Outcomes were assessed with several validated scoring systems, namely the American Knee Society Score (AKSS), Oxford Knee Score (OKS) and Bartlett Patellar Score (BPS) [16]. At that time (20 years ago) preoperative scores were not performed in our unit. Clinical assessment was carried out in an outpatient clinic by arthroplasty care practitioners (ACPs), unless the patient was unable to attend. In these cases and at each review time period, the OKS was obtained via telephone from the patient or a responsible carer. Patient demographics, implant details, clinic notes and scores were recorded on a hospital database. Details of patient death were obtained through the use of the Northern Ireland Electronic Care Record (NIECR), an online healthcare system used to log patient interaction with the health service across the province.

Implant survival was analysed using Kaplan–Meier graphs and life tables with the primary endpoint being revision for any reason. Survival was calculated from the date of the initial operation to one of the following and whichever came first: date of revision, date of death, date of review, or date of last known follow-up. Statistical analysis was carried out using the SPSS statistical package v.22 (IBM, Armonk, New York).

Table 1
Patient cohort, N = 487.

	Knees	Patients
Total	542	487
Bilateral	110	55 (34 females, 21 males) (35 simultaneous, 20 staged)
Gender		
Male	189	168
Female	353	319
Total reviewed	139	120
Attended review	66 (1 revised)	57 (1 revised)
Telephone review	73 (3 revised)	63 (3 revised)
Lost to follow-up	8	8
Deceased	395 (7 revised)	359 (7 revised)

Table 2
Patient demographics.

	Total knees (n = 542)	Reviewed (n = 139)	Deceased (n = 395)	Lost to follow-up (n = 8)
Gender				
Males	189 (34.9%)	55 (39.6%)	132 (33.4%)	2 (25.0%)
Females	353 (65.1%)	84 (60.4%)	263 (66.6%)	6 (75.0%)
Age (years)	69.9 (8.2)	64.0 (8.5)	72.0 (7.0)	69.5 (6.5)
Side				
Left	263 (48.5%)	64 (46.0%)	196 (49.6%)	3 (37.5%)
Right	279 (51.5%)	75 (54.0%)	199 (50.4%)	5 (62.5%)
Height (cm)	165.9 (8.7)	165.9 (8.7)	–	–
Weight (kg)	75.8 (15.0)	75.8 (15.0)	–	–
Body mass index (kg/m^2)	27.5 (5.1)	27.5 (5.1)	–	–

3. Results

The data of the 487 TKA patients (542 knees) is summarised in Table 1. The mean age at time of surgery was 69.9 years (range 30–87). Of the 542 knees, 319 patients (353 knees) were female (mean age 70.2 years, range 30–87) and 168 patients (189 knees) were male (mean age 69.4 years, range 45–86). Thirty-four females (68 knees) and 21 males (42 knees) underwent bilateral TKA (20.3% of knees). Of these, 20 (40 knees) were staged and 35 (70 knees) were simultaneous. Table 2 provides an overview of the demographics of the original cohort.

From the original cohort of 542 knees, a total of 395 (72.9%) knees (359 patients) were lost to follow-up prior to the 20-year review due to patient death, which is attributable to the long duration of follow-up. Average time to death for these patients was 10.9 years. A further eight (1.5%) knees (eight patients) were lost to follow-up as they were unable to be contacted. In total, 11 (2.0%) knees were revised before 20 years. Of the 11 revised cases, two (0.37%) were revised for aseptic loosening, two patients (0.37%) were revised for pain, five (0.92%) underwent secondary patellar resurfacing for postoperative anterior knee pain, one knee was revised for late infection at 15.6 years postoperatively and one knee underwent liner exchange following a spin-out.

Table 3
Revisions.

Gender	Side	Date of operation	Details of revision	Date of revision	Outcome following revision
F	Left	30/10/1995	**Infection**	18/12/1995	Died a month following the revision 19/01/1996.
M	Left	08/01/1996	**Deep infection** Background of rheumatoid arthritis (femoral component loose at revision).	24/08/2011	**Good outcome.** No problems until patient death in Nov 2017.
F	Right	06/07/1995	**Loosening** Pain and disruption of MCL. At revision — osteolysis distal femur, tibial tray loose and marked damage on poly.	17/09/2003	**Continued to complain of anterior knee pain.** Range of motion (ROM) 0–100° — knee stable.
F	Left	20/06/1994	**Loosening** Loose tibial and femoral components.	26/06/2000	Reviewed up until death in 2010, pain free, flexion to 70°.
F	Left	06/12/1995	Pain — **Patellar Resurfacing**	24/10/2001	**NO BETTER.** Never happy after primary knee, and not happy after re-surfacing.
M	Left	15/02/1996	Pain — **Patellar Resurfacing**	10/11/1997	**Good result** Did not settle initially, good result over longer term.
F	Left	05/02/1996	Pain — **Patellar Resurfacing**	17/02/1999	**NO BETTER**
M	Left	09/10/1995	Pain — **Patellar Resurfacing**	02/12/1996	**Good result** Did not settle initially, good result over longer term.
F	Left	26/09/1995	**PAIN** (and some instability) — **Patellar Resurfacing** (1) Revised for pain (insert changed and re-surfaced patella). (2) Revision of tibial component to correct valgus. (3) Excision of presumed infected TKR — CRP 100 pre revision.	(1) 08/08/1997 (2) 23/10/1998 (3) 06/11/2002 and 12/02/2003	**NO BETTER** (1) Pain unresolved following insert change and re-surfacing. (2) Implants well fixed at revision. (3) 1st & 2nd Stage revision. Never settled — ongoing anterior knee pain.
F	Left	25/11/1993	**Unexplained pain.** Flexion only to 20° (pre-op flexion 40°).	14/12/1998	Never settled — **ongoing pain.**
F	Right	29/12/1994	**Unexplained pain** and INSTABILITY (components NOT loose at revision).	22/10/1998	Never settled — **ongoing pain.** Stable knee, ROM 0–120°. Reviewed up until 2017.
M	Right	08/02/1996	**Dislocated/Spin out** & revision of insert.	01/03/1996	**Good result**

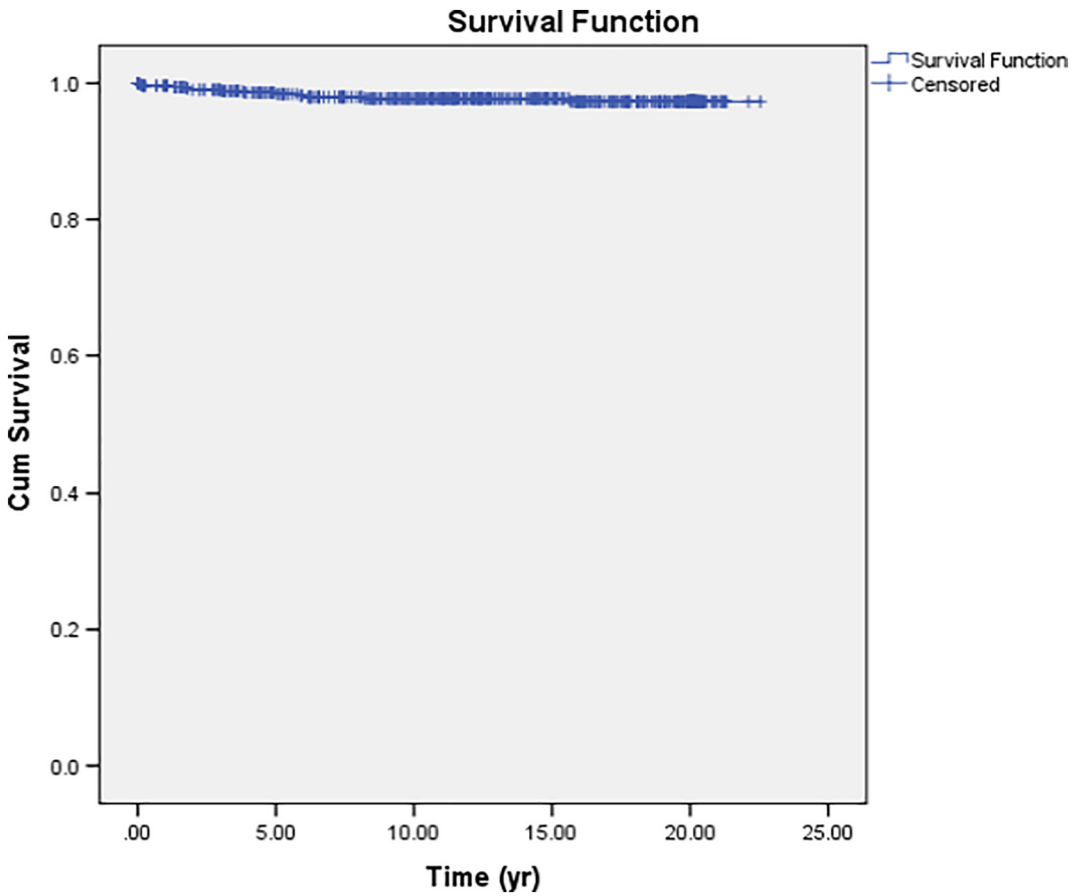

Figure 1. Kaplan–Meier survivorship graph for all revisions.

Average time to secondary patellar resurfacing was 2.7 years. Of the 11 revised cases, five had revision of both components and they were all deceased by 20 years. Of the other six, one was deceased, three had a telephone review and one patient attended the clinic for review at the 20-year follow up. Thus at the time of death or last follow-up, all but five (0.92%) of the knees still had their original femoral and tibial components in situ. Table 3 provides details of the revisions and outcomes. Figure 1 shows the Kaplan–Meier graph for all revisions while Appendix 1 details the life table analysis. The mean survival time was 22.1 years (95% CI 21.9 to 22.4). The cumulative survivorship rate was 98.0% at 20 years, using revision for any reason as the primary endpoint. No patients underwent revision surgery for polyethylene wear.

During the 20-year follow-up period, 14 knees (2.6%) underwent reoperation for reasons other than revision. Twelve (2.2%) underwent manipulation under anaesthetic (MUA) for postoperative stiffness. On average, MUA was undertaken at 4.0 months following primary TKA. One patient sustained a periprosthetic fracture of the distal femur at 7.9 years postoperatively. This patient underwent fixation with a retrograde femoral nail. One patient underwent debridement of the wound two weeks following primary TKA. Table 4 provides details of the reoperations and outcomes. In the patients that have reached the 20-year follow-up, there are no planned reoperations or revisions at the time of writing.

In total, 120 patients (139 knees) were reviewed at 20 years. Of these patients, 57 (66 knees) (47.5%) were able to physically attend the outpatient department for review. The remaining 63 patients (73 knees) (52.5%) were unable to attend in person and were therefore assessed via telephone review.

The OKS [17] is a 12-item patient-reported outcome score specifically designed and developed to assess function and pain after total knee replacement. The scale ranges from 0 points (worst outcome) to 48 points (best outcome). The average OKS for patients attending was 32.4 (range nine to 47). The average OKS for those reviewed over the telephone was significantly worse at 29.2 (range 13–39, $p = 0.024$). For those who attended the mean Clinical AKSS was 87.3 (range 53–100, standard deviation 12.8) and the mean Functional AKSS was 52.5 (range 20–100, standard deviation 19.9). The average BPS for those attending the review was 22.3 (range 11–30, standard deviation 5.2). Patient reported and functional scores are provided in Table 5.

Sixty-six knees were X-rayed at the 20-year follow-up review. Of these 66 knees, 65 (98.5%) knees had no evidence of wear or radiolucent lines (RLLs). One knee (Figure 2) showed evidence of a RLL underlying the tibial component, as shown on the AP radiograph. There were no adverse features demonstrated on any lateral radiographs.

Table 4
Reoperations.

Gender	Side	Date of operation	Details of reoperation	Date of reoperation	Outcome following reoperation
F	Right	30/06/1995	Fracture distal femur	12/06/2003	Treated with retrograde femoral nail
M	Right	06/12/1995	MUA	13/02/1996	**Good result** Pre-MUA ROM 5 to 45°. 0–100° at 5 years post-MUA.
M	Left	27/09/1995	MUA	01/12/1995	**Improvement** ROM 5–40°. At MUA <5 to 110°. Long term flexion to 70°.
F	Right	29/08/1995	MUA	23/11/1995	**Improvement** Pre-op ROM 10 to 45°. MUA to 115°. Long term flexion to 90°.
F	Right	14/03/1995	MUA	18/10/1995	**Improvement** Pre-op ROM 5 to 60°. MUA to 100°. Long term flexion to 70°.
F	Right	12/05/1995	MUA	02/10/1995	**Good result** Fixed at 70° – MUA adhesion broken – allowing flexion to 115°. Long term flexion to 115°.
M	Left	27/02/1995	MUA	28/09/1995	**No Improvement** Pre-op ROM 10–70°. MUA to 100°. Long term flexion to 70°.
F	Right	14/06/1995	MUA	18/08/1995	**Improvement** (slight) Pre-op ROM 5 to 65°. MUA to 100°. Long term flexion to 70°.
M	Left	08/03/1995	MUA	15/08/1995	**Good result** Pre-op ROM 5 to 85°. MUA to 110°. Long term flexion to 105°.
M	Left	27/02/1995	MUA	03/07/1995	**Good result** Pre-op ROM 10–60°. After MUA 10–120°. Long term flexion to 100°.
M	Left	22/03/1995	MUA	14/06/1995	**Good result** Pre-op ROM 20 to 65°. MUA to 100°. Long term 0 to 115°.
M	Left	31/10/1994	MUA	02/03/1995	**Good result** Pre-op ROM 5–45°. MUA 100°. Long term 0 to 90°.
F	Left	05/02/1996	MUA	07/06/1996	**Improvement** Pre MUA ROM 0–40°. MUA ROM 0–100°. Long term 0 to 75°.
F	Left	14/02/1994	Early debridement of wound and suture	01/03/1994	Wound settled and no further problems.

4. Discussion

The data presented demonstrates excellent survivorship and satisfactory clinical function at a minimum 20-year follow-up using the LCS RP cemented TKA prosthesis. The cumulative survivorship of this patient cohort was 98.0% at 20 years with 99% of knees still having their original femoral and tibial components in situ at the time of death or long-term follow-up. This is comparable to the excellent results shown in previous long-term LCS patient cohorts [18] and adds to the body of evidence supporting long-term survivorship of this mobile bearing knee replacement.

Table 5
Patient reported and functional scores at 20-year follow-up.

	Oxford Knee Score	American Knee Society Score (Clinical)	American Knee Society Score (Functional)	Bartlett Patellar Score
Total reviewed	30.7 (range 9–47, SD 7.7)	87.3 (range 53–100, SD 12.8)	52.5 (range 20–100, SD 19.9)	22.3 (range 11–30, SD 5.2)

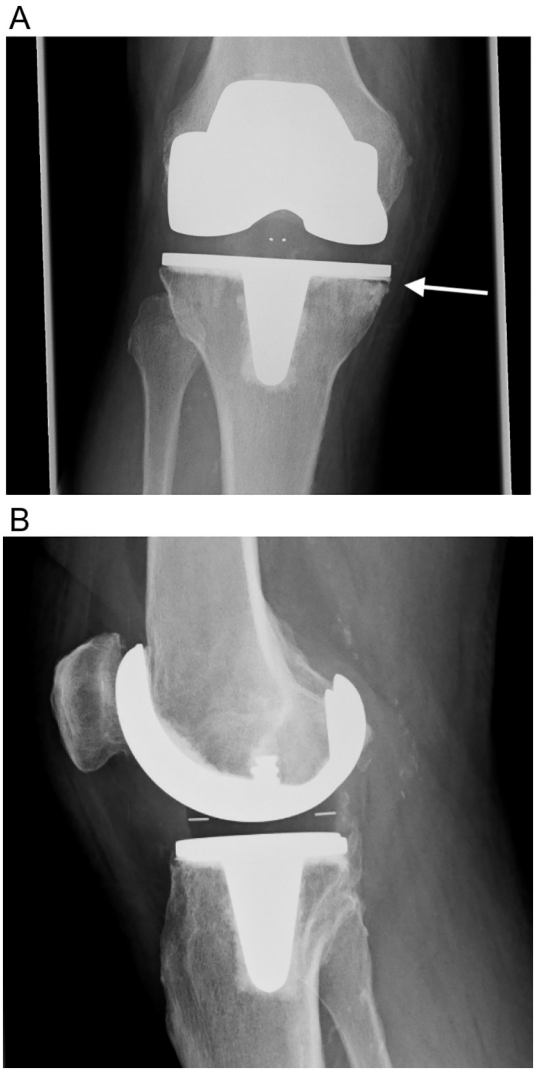

Figure 2. AP and lateral standing radiographs of patient at 20-year follow-up, with radiolucent line (RLL) underlying the tibial component (arrow).

Recent data from the 14th UK National Joint Registry report has shown that 94.3% of all primary total knee replacements carried out in the UK last year used cemented implants [12]. Concern remains over some aspects of cemented TKA, including late aseptic loosening due to tension and shear forces through the bone–cement–implant interfaces. In addition, accumulation of cement debris in the joint is another possible mechanism for late-stage failure of cemented knees [18].

Aseptic loosening, most commonly affecting the tibial component [19,20], remains the single most common cause for late-stage failure in TKA. However, in this series, aseptic loosening occurred in <1% of knees (two out of 11 revisions), which may be attributable to the protective effect of the mobile bearing. Of the other nine revisions, five were secondary patellar resurfacings. However, following the unsatisfactory outcome of secondary patellar resurfacings in this knee design, the senior author has not performed a secondary resurfacing since 2003 [21]. In this total cohort, 24 knees (4.4%) had a primary patellar resurfacing but this stopped within the senior authors practice from 1996. Revision for instability is another common reason for revisions in most series [20], but there was only one bearing revision for instability in this series as a result of a bearing spinout. Consequently, we do not feel that bearing spinout is a major issue in the mobile bearing knee with the majority of bearing spinouts now being reduced closed with no recurrence [22].

Two patients from the original cohort underwent revision surgery for persistent postoperative knee pain. Neither of these patients had evidence of loosening or deep infection at the time of revision surgery. Both patients had ongoing pain, which did not settle after revision surgery. It is well recognised that a subset of patients undergoing primary TKA will experience dissatisfaction postoperatively, with overall satisfaction rates between 80 and 90% [23,24]. It is our practice to follow up TKA patients at an early stage postoperatively to allow early identification of dissatisfied patients [25]. Knee function was measured at the 20-year review appointment using the AKSS. Mean Clinical AKSS of 87.3 and mean Functional AKSS of 52.5 show good functional outcomes in this

patient population at the 20-year follow-up, and are again consistent with previous data [18]. However, the AKSS itself has been criticized for displaying high intra- and inter-observer error rates [26]. It is important to note that the OKS for this cohort was worse for those patients who were unable to attend their appointment and therefore underwent telephone review. By implication, patients that are unable to attend clinical review for medical reasons are likely to have a worse score.

The major limitations of this study are firstly, the 395 (72.9%) knees in 359 patients that were lost to follow-up due to death, and eight further patients lost to follow-up as they were unable to be contacted. Secondly, we have assumed that we have been made aware of all revisions. Patients were questioned directly about revision surgery, and patient notes were examined at the time of clinical review to ensure that no interventions were overlooked. It is possible that revision surgery was carried out in another unit without the knowledge of the primary author. However, we do have a uniquely captive population and believe that we are made aware of complications and particularly revisions through the close working relationship of surgeons in Northern Ireland. In addition, only 66 of 139 patients reviewed at 20 years underwent radiographic analysis. Therefore, it is possible that patients with impending radiological failure have been underappreciated.

Recent registry data has raised some concerns with regard to the risk of aseptic loosening for mobile-bearing TKA when compared with fixed bearing implants [28]. It is true that to date, evidence has not shown the benefits of mobile bearing TKA that were postulated from in vitro studies. However, our study shows good survivorship and a low rate of revision with a mobile bearing knee that does not correlate with the registry data. Mobile bearing TKA is thought to be more prone to malalignment and instability [28], which may account for some difference in the revision rates versus a fixed bearing implant. In addition, our patient population was elderly and low demand over the implant lifetime, meaning that the excellent survivorship demonstrated may not be generalisable to a younger more active patient cohort. Further long-term research will be necessary to assess mobile bearing performance in the young active patient.

5. Conclusions

This patient cohort shows excellent survivorship of 98.0% at 20 years using revision for any reason as the primary endpoint with a fully cemented mobile bearing knee.

Declaration of Competing Interest

Although none of the authors has received or will receive benefits for personal or professional use from a commercial party (DePuy Orthopaedics International, Leeds, UK) related directly or indirectly to the subject of this article, benefits have been or will be received but will be directed solely to a research fund, foundation, educational institution, or other non-profit organisation with which one or more of the authors are associated.

Appendix 1. Life table survival analysis

Start time	Entering (n)	Withdrawing (n)	Exposed to risk (n)	Revisions (n)	Cumulative proportion surviving	Hazard rate	Standard error of hazard rate
0	542	17	533.5	2	1.00	0.00	0.00
1	523	15	515.5	3	0.99	0.01	0.00
2	505	13	498.5	0	0.99	0.00	0.00
3	492	19	482.5	2	0.99	0.00	0.00
4	471	17	462.0	0	0.99	0.00	0.00
5	454	14	447.5	2	0.98	0.00	0.00
6	438	13	431.5	1	0.98	0.00	0.00
7	424	13	417.5	0	0.98	0.00	0.00
8	411	15	403.5	1	0.98	0.00	0.00
9	395	24	383.5	0	0.98	0.00	0.00
10	371	25	358.5	0	0.98	0.00	0.00
11	346	31	330.5	0	0.98	0.00	0.00
12	315	30	300.0	0	0.98	0.00	0.00
13	285	13	278.5	0	0.98	0.00	0.00
14	272	24	260.0	0	0.98	0.00	0.00
15	248	23	236.5	1	0.97	0.00	0.00
16	224	23	212.5	0	0.97	0.00	0.00
17	201	22	190.0	0	0.97	0.00	0.00
18	179	21	168.5	0	0.97	0.00	0.00
19	158	45	135.5	0	0.97	0.00	0.00
20	113	103	61.5	0	0.97	0.00	0.00
21	10	8	6.0	0	0.97	0.00	0.00
22	2	2	1.0	0	0.97	0.00	0.00

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