The Avon patello-femoral joint replacement: 2 to 18-year results of a large single centre cohort.

Accepted authors manuscript for the Bone and Joint Journal
https://online.boneandjoint.org.uk/journal/bjj

A.J.Metcalfe[2]*

N.Ahearn[1],

M.A.Hassaballa[1],

N.Parsons[2],

C.E.Ackroyd[1],

J.R. Murray[1],

J.Robinson[1],

J.D.Eldridge[1],

A.J.Porteous[1].

From:

1. The Avon Orthopaedic Centre, Southmead Hospital, Bristol, BS10 5NB
2. Warwick Medical School, Warwick University, Coventry, CV4 7AL

*corresponding author

email: a.metcalfe@warwick.ac.uk

tel: 02476965064 (secretary: Kathy O'Malley)

Abstract

Aims

This study reports on the medium to long-term implant survivorship and patient-reported outcomes for the Avon patello-femoral joint (PFJ) replacement.

Patients and Methods

558 Avon PFJ replacements in 431 patients, with minimum two-year follow-up, were identified from a prospective database. Patient-reported outcomes and implant survivorship were analysed, with follow-up of up to 18 years.

Results

Outcomes were recorded for 483 implants, representing an 86% follow-up rate. The median post-operative Oxford Knee Score (0-48 scale) was 35 (IQR 25.5-43) and the median WOMAC (0-100 scale) was 35 (IQR 25-53) at two years. There were 105 revisions, 61 (58%) for progression of osteoarthritis. All documented revisions were to primary knee systems without augmentation. The implant survival rate was 77.3% at 10 years and 67.4% at 15 years. Cases performed in the later nine years of the study had a significantly (p=0.039) improved survival (91.8%) compared with those performed in the first nine years (78%). Regression analysis of explanatory data variable showed that the operating surgeon had the strongest effect on survivorship.

Conclusion

Good long-term results can be obtained with the Avon patello-femoral replacement, with maintenance of PROMs, acceptable survival and low rates of loosening and wear.

Introduction

Isolated patello-femoral osteoarthritis can cause significant disability and is common, affecting between 11 and 24% of the population with knee pain[1]. Several arthroplasty options have been developed with the aim of replacing the patello-femoral joint in isolation. Outcomes for various implants have been reported, with varying degrees of success, but these studies are limited in terms of the numbers of cases or length of follow up[2-7].

The Avon (Stryker Orthopaedics, Mahwah, New Jersey) patello-femoral joint (PFJ) replacement was introduced in 1996 with the aim of resolving some of the problems experienced with earlier designs[2]. The trochlear component has an onlay design. Its position, in terms of flexion, offset and external rotation is not defined by the native anatomy, which is often dysplastic[8]. Proximally there is a broad articulating trochlear surface that narrows and becomes more congruent in flexion, and the patella button has an offset dome design. The Avon has become one of the most popular designs for PFJ replacement worldwide, and has been the most common PFJ implant on the UK National Joint Registry (NJR) since its inception[9].

As the Avon Orthopaedic Centre, we have maintained a prospectively collected database of all cases performed since the introduction of the implant. This has been reported on previously, although in earlier publications the follow up was relatively short and the cohort represented the early group of patients treated with this device, without reference to current practice and indications[2,3].

The aim of this paper is to report on the long-term results of the Avon patello-femoral replacement over the full history of this large single-centre cohort, with minimum of 2-years and a maximum of 18-years follow up.

Patients and Methods

This study was performed as a clinical effectiveness project and had formal approval from the local clinical governance department. The Avon patello-femoral database (Microsoft Access, Microsoft, USA) has been prospectively collected in Bristol since the implant was first introduced in 1996. All Avon patello-femoral replacements performed by any of the surgeons in the unit (private or NHS) were entered into the database which is managed and maintained by the Bristol Knee Group.

Demographic data included: patient age, primary diagnosis, prior operations and (for cases of primary osteoarthritis) pattern of disease at surgery. Post-operatively, hard end-points were recorded including death and revision of the implants. The reason for revision and the implant used was documented and if a revision was performed in another centre, then the surgical team was contacted for details of the date and the reason for revision. The WOMAC score (expressed as a percentage, 0 being the best score), and the Oxford Knee Score (OKS) (0-48, 48 being the best score) were collected pre-operatively and at one, two, five, eight, ten, twelve and fifteen years routinely[10,11]. Assessments were performed in clinic, however patients who did not attend clinic or were beyond 15 years since their operation were contacted by postal survey. Non-responders to postal contacts were followed up by a telephone interview. The dataset was comprehensively reviewed and updated with new postal and telephone follow-ups in 2014 and this paper represents a full analysis of those data, giving follow-up for the longest surviving implants of 18 years.

Only primary Avon patello-femoral replacements were included in the analysis. There were no other selection criteria and as such this represents a consecutive series. A minimum follow-up period of two years was set, based on previous studies showing that outcome after total knee replacement (TKR) cannot be fully determined until two years[12].

Data were extracted into Microsoft Excel (Microsoft, USA) and this was used to calculate medians, standard deviations and 95% confidence intervals for the outcome scores. The Kaplan-Meier method was used to determine implant survival. A Cox proportional hazard regression analysis was performed

to examine the relationship between implant survival and explanatory data variables: patient age, gender, diagnosis at time of surgery, individual surgeon and implantations performed in the first and last 9 years of the study. This split of the cohort was to assess the difference in implant survival and outcome between the initial use of the implant and current, contemporary practice. Age groups were assigned as those under the age of 50, and then by decades up to the age of 80 and over. Surgeons who had performed over ten cases were given an anonymous numerical code to assess individual surgeon effects without assessing named individuals, and these data were analysed with strict anonymity. Diagnosis at operation was established from a list of options: lateral facet OA, medial facet OA, symmetrical OA, subluxation, dislocation, post-traumatic, anterior knee pain. The diagnosis of dysplasia was added in the last seven years of the cohort. Linear regression models were also fitted to assess the association between year two OKS and WOMAC scores and explanatory data variables; a stepwise backwards elimination algorithm was used to find the best subset of explanatory variables for each model. Two-year outcomes were chosen for this analysis as this has been shown to be the peak outcome achieved after total knee replacement[12]. The survival and regression analyses were performed using R[13] and significance was set at the 5% level. Medians were used to summarise the PROMS data and the variability was quantified using the interquartile range, to allow comparability with PROMs data reported from the NJR[14,15].

Results

There were 558 cases performed in 431 patients over the full two to eighteen-year series, of which 357 cases in 268 patients were performed over ten years ago. There were 351 females and 80 males and the mean age was 58.8 (range 25-92). The mean age at time of surgery fell gradually over the course of the study, from 69.8 in the first year to 52.8 in the last year, as demonstrated in Figure 1.

The outcome (defined as whether the implant had been revised or was known to be in situ) was determined in 483 cases representing an 86% rate of follow up. There were 73 deaths, none of which were known to be related to the procedure. With those who had died or been revised excluded, the outcome was determined in 295 of 370 cases, giving an 80% follow-up rate of surviving implants.

There were 105 revisions in 93 patients. Four of the revisions were to further PFJ replacements (three to another Avon and one to a Smith and Nephew Journey), 90 revisions were to standard total knee replacements with no cases requiring stems, augments or revision implants. The revision implant used was unknown in 11 cases. The reasons for revision are documented in Table 1, the majority were for progression of osteoarthritis. The ten-year survival rate for the whole cohort was 77.3% (95% CI 72.4 to 81.7%) and the fifteen-year survival rate was 67.4% (95% CI 57.1 to 74.3%) (Figure 2). The Cox proportional hazard regression analysis showed that age, gender and diagnosis had no effect on implant survival ($p=0.218$, $p=0.245$ and $p=0.993$ respectively from likelihood ratio tests). Comparison between the cohort with less than nine-year follow-up and the with nine to eighteen-year follow-up cohort was significant ($p=0.039$) and the effect of the individual surgeon was strong ($p=0.001$). Those cases performed within the last nine years had a 91.8% (95% CI; 66.5 to 97.1%) survival out to nine years as opposed to a 79.1% (95% CI; 74.7 to 83.6%) survival at nine years for the cases performed in the earlier half of the cohort. Data were sparse for the former group at longer follow-up times, so consequently confidence intervals were wide.

The OKS (0-48) and WOMAC (0-100) scores for patients with surviving implants are given in Table 2. The median improvement in OKS was 16 points from 19 (IQR 14-26) pre-operatively to 35 (IQR 25.5-

43) at 2 years. The median WOMAC score improved by 27, from 62 (IQR 48-70) pre-operatively to 35 (IQR 25-53) two years post-operatively. The improvement in scores was maintained over the fifteen-year period of the study, with a median fifteen-year OKS of 35 (IQR 25-41.5) and a median WOMAC score of 37 (IQR 23-45).

For both two-year OKS and WOMAC scores, there were two statistically significant explanatory variables in the regression models, age and diagnosis. For OKS p=0.036 for age group and p=0.004 for diagnosis group, and for WOMAC p=0.032 and p=0.013 respectively. Regression coefficient estimates for OKS are displayed in Figure 3. OKS and WOMAC models showed very similar patterns, due in large part to the strong correlation between these PROMS (-0.95; 95% CI -0.96 to -0.93). Overall model fits were very modest, accounting for only 10% and 13% of the variation the OKS and WOMAC scores respectively.

With regard to age, the lowest outcome scores were seen in the under 50 age group, with scores in the age group 60-70 being the highest (Figure 3a). With regard to diagnosis, the worst scores occurred in those treated for anterior knee pain, medial facet OA and post-traumatic OA, whereas better scores were seen in those with lateral facet OA, dislocation and subluxation (Figure 3b).

Discussion

The Avon patello-femoral joint replacement has been in use in the Avon Orthopaedic Centre for over eighteen years and during that time it has been used by eleven different surgeons. Whilst this study includes patients from the designer surgeon, three quarters of the patients in the series were performed by non-designer surgeons and as such it represents a broader experience over a prolonged time period. To our knowledge this is the largest series of patello-femoral replacements outside of the registries with amongst the longest follow-up times in the literature. From these data, we can conclude that the Avon patello-femoral replacement can provide good functional outcomes, maintained over a prolonged period with acceptable survivorship, particularly if used with contemporary indications.

The PROMs and variability found in this study are similar to those reported in the UK NJR for the Avon patello-femoral replacement. The one year post-operative OKS for our cohort was 35 compared to 34 in the UK NJR[14]. Whilst these scores are similar to those reported for TKR, the patient populations are different in age, in pattern of disease and in symptoms. We did not capture PROMs that assess higher levels of function as the choice of measures was made at the start of data capture in 1996, before such measures (like KOOS or OKS-APQ) were widely available or reported on. Future studies and cohorts now being set up may wish to consider this in their design.

Randomised controlled studies comparing PFJ replacement and TKR are currently being undertaken but have not yet been reported in the literature. The two-year results of a randomised trial comparing the Avon patello-femoral replacement to the PFC Sigma total knee replacement for isolated patello-femoral osteoarthritis, blinded for the first post-operative year, were presented at the British Orthopaedic Association Congress in 2017[16]. Superior patient reported outcomes were found for the arm who received the Avon replacement.

In our study, the overall implant survival at ten years was 77.3.% This is comparable to 81.3% for patello-femoral replacements found in the UK NJR 2016 report[9]. We found that implant survivorship

improved in the later half of the 18-year follow-up period, with nine-year survivorship of 91.8% for cases performed in the later 9 years. Refinements in surgical technique, instrumentation and surgical indications could all be responsible for the improved survivorship in the latter half of the cohort. With time and evolving experience with the implant, usage indications have gradually evolved. The decline in patient's mean age at surgery throughout the study is indicative of this and probably reflects our increasing tendency over time to recommend PFJ replacement in younger patients with trochlea dysplasia or a history of patella instability. Whereas, in the early years, implant usage was restricted to older individuals with advanced disease.

The individual surgeon was found to have the most significant impact on the revision rate. This could be the result of both patient selection and surgical technique. However, the difference seen in frequency of revisions for progression of osteoarthritis suggests that patient selection is likely to be the most important of these factors. Patient age was not a predictor of survival of the implant, but did have an effect on the outcome score at two years. The same pattern of lower scores in younger individuals has been noted for TKR previously and therefore is not unique to PFJ[12,17]. Again, this supports the need for further comparative trials in suitable patients where age groups are appropriately balanced.

Diagnosis at the time of surgery was not found to be a significant factor in predicting implant survival. It was, however, influential for patient reported outcomes, with subluxation and dislocation being associated with better outcomes and anterior knee pain and post-traumatic disease being associated with poorer outcomes. Whilst the exact criteria for undertaking PFJ replacement may have varied between surgeons, the recommendation that patients should have full thickness chondral loss isolated to the patello-femoral joint has remained as a pre-requisite for surgery.

The diagnosis of trochlear dysplasia was only entered into our database relatively recently as a separate diagnosis, and there were no formal criteria defined for this, which may explain why this did not affect outcomes in this study. It has previously been reported that a pre-operative diagnosis of

dysplasia is associated with better results with PFJ replacement, presumably as this is a structural cause for single joint disease which is resolved by the replacement[18]. We did however note better outcomes in patients with subluxation and dislocation which are commonly associated with trochlear dysplasia and it may be anticipated that with longer follow up, the presence of trochlear dysplasia may prove to be an important predictor of outcome in our series.

In our series, the majority of revisions were for progression of disease in other compartments. We did not investigate the pattern of disease progression or which compartments were involved. Implant loosening and wear were rare events with only 13 known cases out of the 558 implantations.

Revisions of Avon patello-femoral replacements were consistently to a primary implant, with no need for stems or augments in any case. A PFJ replacement can therefore genuinely be considered a less invasive option on the arthroplasty ladder. The ease with which patello-femoral replacements, similar to other unicompartmental replacements, may be revised has a significant impact upon survivorship. Revision rates would be expected to differ between patello-femoral replacements and total knee replacements, which have much lower revision rates, but are typically much more complex to revise with greater surgical morbidity. The twelve revisions that were for pain with no cause identified should in particular be highlighted, as this is not recommended by the authors and we would only recommend revision where a specific treatable problem can be identified and managed with further surgical intervention.

There are weaknesses in this study. Follow up was not complete and missing data has the potential to affect the findings. However, the rate of follow up was reasonable considering the length of follow-up and as such this represents one of the most reliable sources of data on the overall survival of the Avon patello-femoral replacement. Pre-operative radiographs were no longer available for many cases, especially those cases in the earlier part of the series, and diagnostic codes were relatively subjective and were not formally defined. The diagnosis data presented in Figure 5b should be interpreted cautiously. The influence of important patient selection factors such as the presence of

dysplasia, or osteophytes in the other compartments, can therefore not be determined. Future studies with radiological or cross-sectional imaging of the trochlea may be able to define the relationship between pre-operative dysplasia and post-operative outcome.

Conclusion

This large cohort study of a single implant demonstrates that good results can be obtained with the Avon patello-femoral replacement in the long-term. Both surgeon and patient factors are important in achieving good post-operative outcomes. Survivorship has improved over time, reflecting the contemporary understanding of the most appropriate indications and refinement of surgical techniques. Good maintenance of patient outcome scores, acceptable survival and very low rates of loosening or wear were observed up to 18 years after the primary operation.

Tables and Figures

Table 1. Reasons for revision. The number of causes totals 108 as there are three cases in which both femoral loosening and tibiofemoral progression were recorded by the surgeon.

Cause for revision	**Number**
OA progression	61
Pain (cause unknown)	12
Femoral loosening	7
Button wear	6
Mal-alignment or mal-sizing*	2
AVN femoral condyle	2
Unknown/not recorded	18

Table 2. Oxford Knee Scores (0-48, 48 the best score) and WOMAC scores (0-100, 0 the best score) over the study period, expressed as medians and interquartile ranges (IQR).

	Number of cases with PROMs	Oxford Knee Score		WOMAC	
		Median	IQR	Median	IQR
Pre-op	524	19	14-25	62	48-70
1 year	321	35	24.5-42	37	25-52
2 years	346	35	25-43	35	25-53
5 years	196	34	22-43	36	23-55
8 years	131	33	21-39.5	38	25-63
10 years	125	32	21-40.5	37.5	26.5-60
12 years	72	32.5	24.5-41.5	43	26.5-56
15 years	37	35	20-41	35	23-45

Figure 1. Mean age at time of surgery plotted in year groups from the start of the study

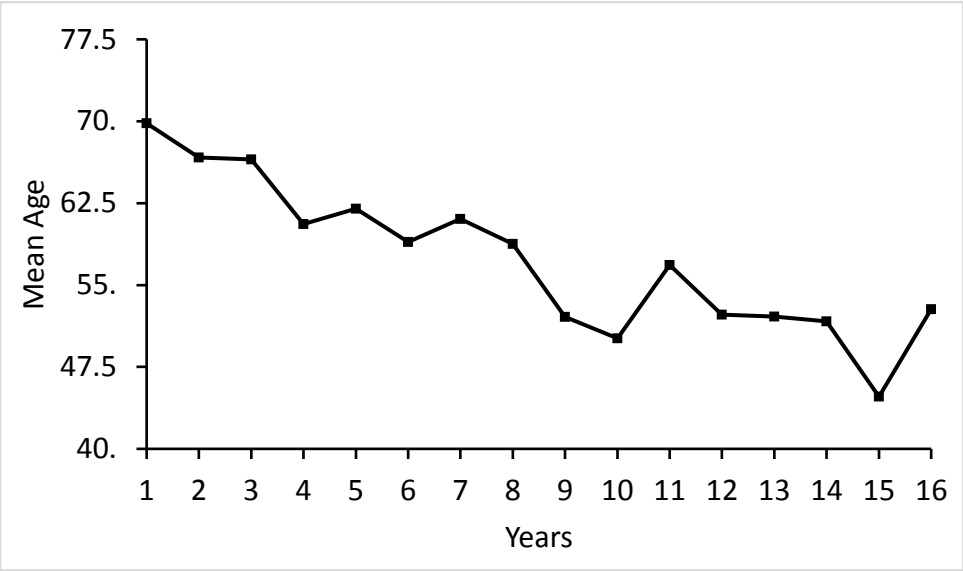


Figure 2. Estimated proportion of patients unrevised (Kaplan-Meier curve) for the full cohort, with 95% confidence intervals (shaded)

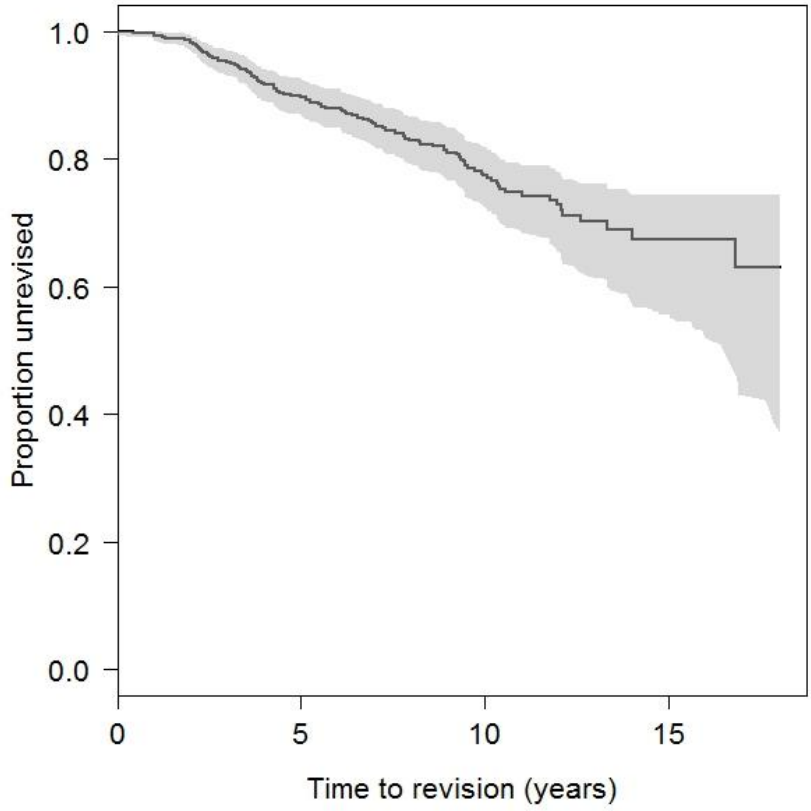
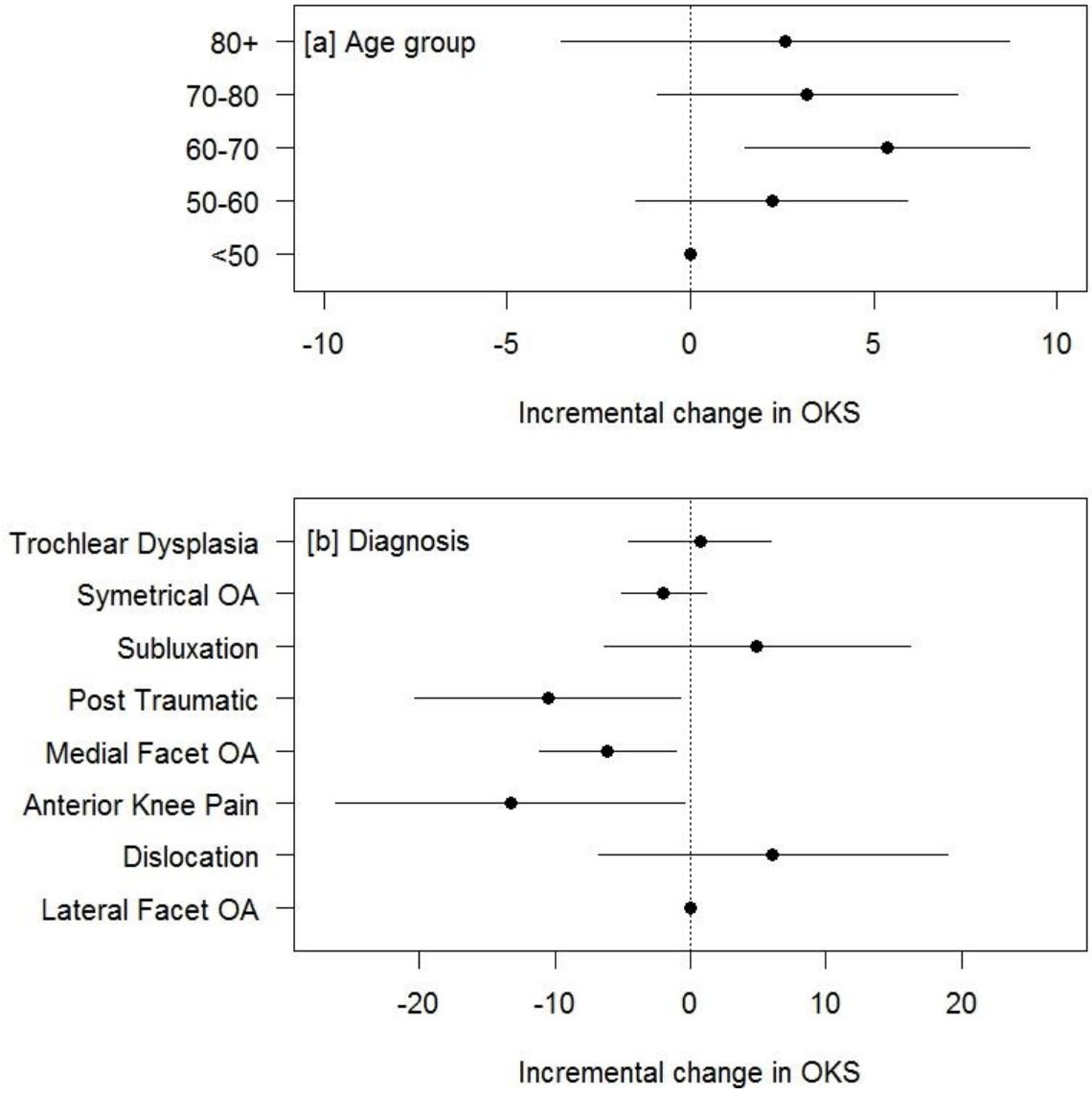


Figure 3. Incremental changes (that is, the difference between groups, relative to a reference group) in the two-year Oxford Knee Score (OKS) for the two factors that were significant in the linear regression analysis a) Age Group and b) Diagnosis. The reference groups were a) patients aged under 50 and b) those with lateral facet osteoarthritis (OA).



References

1. **McAlindon TE, Snow S, Cooper C and Dieppe P.** Radiographic patterns of osteoarthritis of the knee joint in the community: the importance of the patellofemoral joint. *Annals of the Rheumatic Diseases*. 1992; 51: 844-9.
2. **Ackroyd CE.** Development and Early Results of a New Patellofemoral Arthroplasty. *Clinical Orthopaedics and Related Research*. 2005; &NA;: 7-13.
3. **Ackroyd CE, Newman JH, Evans R, Eldridge JDJ and Joslin CC.** The Avon patellofemoral arthroplasty: five-year survivorship and functional results. *The Journal of bone and joint surgery British volume*. 2007; 89: 310-5.
4. **Mont MA, Johnson AJ, Naziri Q, Kolisek FR and Leadbetter WB.** Patellofemoral arthroplasty: 7-year mean follow-up. *The Journal of arthroplasty*. 2012; 27: 358-61.
5. **Odumenya M, Costa ML, Parsons N, Achten J, Dhillon M and Krikler SJ.** The Avon patellofemoral joint replacement: Five-year results from an independent centre. *The Journal of bone and joint surgery British volume*. 2010; 92: 56-60.
6. **Morris MJ, Lombardi AV, Berend KR, Hurst JM and Adams JB.** Clinical results of patellofemoral arthroplasty. *The Journal of arthroplasty*. 2013; 28: 199-201.
7. **van Jonbergen H-PW, Werkman DM, Barnaart LF and van Kampen A.** Long-term outcomes of patellofemoral arthroplasty. *The Journal of arthroplasty*. 2010; 25: 1066-71.
8. **Mofidi A, Veravalli K, Jinnah RH and Poehling GG.** Association and impact of patellofemoral dysplasia on patellofemoral arthropathy and arthroplasty. *The Knee*. 2014; 21: 509-13.
9. **National Joint Registry Editorial Board.** National Joint Registry 13th Annual Report. 2016.
10. **Bellamy N, Buchanan WW, Goldsmith CH, Campbell J and Stitt LW.** Validation study of WOMAC: a health status instrument for measuring clinically important patient relevant outcomes to antirheumatic drug therapy in patients with osteoarthritis of hip or knee. *Journal of Rheumatology*. 1988; 15: 1833-40.
11. **Dawson J, Fitzpatrick R, Murray D and Carr A.** Questionnaire on the perceptions of patients about total knee replacement. *Journal of Bone and Joint Surgery (British Edition)*. 1998; 80: 63-9.
12. **Williams DP, Blakey CM, Hadfield SG, Murray DW, Price AJ and Field RE**. Long-term trends in the Oxford knee score following total knee replacement. *Bone and Joint Journal*. 2013; 95-B: 45-51.
13. **R Core Team.** *R: A language and environment for statistical computing.* 2017 https://www.r-project.org/.
14. **National Joint Registry Editorial Board.** National Joint Registry: 11th Annual Report. 2014.
15. **National Joint Registry Editorial Board.** National Joint Registry 12th Annual Report. 2015.
16. **Odgaard A, Madsen F, Kristensen P, Kappel A and Fabrin J.** A Randomised Clinical Trial on Patellofemoral vs. Total Knee Replacement for Patellofemoral Osteoarthritis. *British Orthopaedic Association Annual Congress, Liverpool*. 2017.
17. **Williams DP, Price AJ, Beard DJ, et al.** The effects of age on patient-reported outcome measures in total knee replacements. *Bone Joint J*. 2013; 95-B: 38-44.
18. **Dahm DL, Kalisvaart MM, Stuart MJ and Slettedahl SW.** Patellofemoral arthroplasty: outcomes and factors associated with early progression of tibiofemoral arthritis. *Knee surgery, sports traumatology, arthroscopy : official journal of the ESSKA*. 2014; 22: 2554-9.