Fixed bearing, all-polyethylene tibia, lateral unicompartmental arthroplasty - a final outcome study with up to 28 year follow-up of a single implant

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Conflict of Interest Statement

Each author certifies that he or she has no commercial associations that might pose a conflict of interest in connection with the submitted article. Research grant to allow long term follow-up of the patient cohort from Aquilant has been openly disclosed, but Aquliant has had no involvement in this paper.

Ethical Review Committee Statement

Paper was written using routinely collected and anonymised data, and therefore research ethical approval was granted upon this fact.

Abstract

Background:

Lateral unicompartmental arthroplasty (UKA) constitutes only 5-10% of all unicompartmental replacements performed. Whilst the short and medium term benefits are well documented, there remains concern regarding the higher revision rate when compared with total knee replacement. We report the long term clinical outcome and survivorship of a large series of lateral UKA.

Patients and Methods:

Between 1974 and 1994, 71 patients (82 knees) underwent a lateral fixed-bearing St Georg Sled UKA. Prospective data was collected pre-operatively and at regular intervals post-operatively using the Bristol Knee Score (BKS), with later introduction of the Oxford Knee (OKS) and Western Ontario MacMaster (WOMAC) scores. Kaplan Meier survival analysis was used, with revision, or need for revision, as end point. 85% of the patients were female. No patients were lost to follow-up.

Results:

Functional knee scores improved post-operatively up to 10 years, at which point they demonstrated a steady decline. Survivorship was 72% at 15 years, and 68% at 20 and 25 years. Nineteen knees were revised, with progression of disease in another compartment the commonest reason. There were two revisions due to implant fracture. In patients aged over 70 years at time of index procedure, 81% died with a functioning prosthesis in situ.

Conclusion:

This represents the longest follow-up of a large series of lateral UKA. Results of this early design of fixed bearing UKA demonstrate satisfactory long term survivorship. In elderly patients, further intervention is rarely required. More contemporary designs or techniques may show improved long term survivorship in time.

1. Introduction

The short term benefits of unicompartmental (UKA) over total knee arthroplasty (TKR) are supported by robust evidence. Advantages include a shorter procedure, less requirement for blood transfusion, lower risk of thromboembolic events, stroke and myocardial infarct, lower mortality risk at all time-points, and a reduced length of hospital stay [1]. Early patient reported outcomes are also better for UKA, with more patients reporting excellent results and being highly satisfied with the procedure [2-5]. In addition, health economic analysis makes it increasingly attractive for use in publicly funded healthcare systems [5-8]. Subsequently the volume of UKA is increasing, and now comprises approximately ten percent of knee arthroplasty performed in the UK [9].

Lateral compartment replacement only constitutes between five and ten percent of all UKA performed [10-12]. Early published results for lateral UKA were mixed - some older series with cohorts that combined both medial and lateral UKAs showed satisfactory results for the lateral side [13-16], whereas others found the results to be inferior than when performed for the medial side [17]. This early difference may simply reflect lesser surgeon experience of a more infrequently performed procedure, or alternatively reflect an incomplete appreciation of the differences in biomechanics of the two tibiofemoral compartments [18-20]. More recent cohort studies of contemporary techniques and prosthetic design that take into account these differences are subsequently reporting better mid- and long term survivorship [10, 21-24]. Mobile bearing prostheses were introduced in an attempt to reduce polyethylene wear, which would in theory be suitable for the increased translation in the lateral compartment. However, whilst mobile bearing continues to show good results in the medial compartment, there have consistently been problems with bearing dislocation when used on the lateral side [12, 25-29]. Subsequently there has been a gradual shift towards the use of fixed bearing prostheses in the lateral compartment [9, 12].

With ongoing concerns regarding higher revision rates for UKA [9, 30, 31], it is important that long term outcomes and survivorship are established. This paper aims to define the long term survivorship and functional outcome of lateral unicompartmental replacement, reporting the results of a large series of one of the earliest prostheses to be widely used.

2. Methods

2.1 Participant details

Between November 1974 and December 1994, data was collected prospectively from 71 patients (82 knees). All procedures were performed by 4 surgeons. One patient had no identifiable data, and was therefore excluded, leaving 70 patients (81 knees) for follow up. Eleven patients had bilateral procedures, but not at the same sitting. Mean patient age at the time of index procedure was 70 years (range 35-91yrs). 60 (86%) patients were female and 10 male.

The indication for surgery was lateral unicompartmental OA of the knee—as defined by complete loss of lateral tibiofemoral joint space on plain antero-posterior, weight-bearing or Rosenberg (45 degree postero-anterior) knee radiographs, with correctable valgus deformity and no evidence of joint space narrowing in the medial tibiofemoral compartment. Cruciate or collateral ligamentous insufficiency, fixed flexion of more than 10 degrees, flexion of less than 90 degrees, and significant lateral facet or global patello-femoral osteoarthritis were considered absolute contraindications to unicompartmental replacement.

Prospective data was collected on all patients pre- and post-operatively at 1, 2, 5, 8, and 10 years, and then at regular intervals up until 28 years. Patients were initially scored using the Bristol Knee Score (BKS), which provides categorical values for pain, general function and knee function [32]. A total score of more than 90 is considered to be excellent, 80 to 89 good, 70 to 79 fair, and less than 70 poor. During follow-up, more contemporary reporting measures were developed, and so the Oxford Knee and Western Ontario MacMaster (WOMAC) scores are reported in addition from 1999. Anteroposterior, lateral and sky-line radiographs of the knee were taken at each follow-up interval to monitor disease progression and signs of prosthetic failure. Patients who declined face-to-face follow-up completed either postal questionnaire or telephone interview conducted by a trained research nurse or orthopaedic surgeon. This was necessary for 3 patients at 18 years follow up and 2 patients at 25 years follow up respectively. Revision or necessary revision of the prosthesis for any reason was used to define 'failure' for the survivorship analysis

2.2 Prosthesis and surgical technique

The St Georg Sled (Waldemar Link, Hamburg, Germany) was used in our unit between 1974 and 1994, however it is still manufactured today. It consists of a cemented all-polyethelene (ultra-high molecular weight) tibial component, with a flat articular surface (Figure 1). The femoral implant consists of a cobalt chrome, biconvex component, which is cemented. The tibiofemoral articulation formed is unconstrained and non-congruous. The modern- day Sled has the exact same geometry and is still available in an all-polyetheylene form for the tibia, but is also available in a modular metal-backed tibial variant.

When this procedure was first performed, a medial para-patella approach was used, which would tend to internally rotate the sagittal cut on the tibia. As familiarity with the technique improved, a lateral approach was favoured, with the aim to reproduce the technique used through the medial side. Knowledge of the screw-home mechanism affecting tibiofemoral rotation was available in the 1960's [33]. We do not have records documenting a specific degree of internal rotation used in the early years of the cohort, but the earliest memories of the surgeons performing the cases, was that a degree of internal rotation was incorporated on the tibia. The proximal tibial resection was performed using a simple extra-medullary alignment jig.The tibial keel cut was marked and cut freehand. Femoral preparation was performed using a series of templates which allowed selection of the size and a decision regarding placement of the implant - this was a judgement based on coverage and shape match of the curvature of the selected size. Femoral peg holes were marked using the templates. Cartilage was then removed freehand using saw and curettes, and lug holes drilled. Balancing of the knee was performed using trial spacers, similar to standard contemporary techniques.

2.3 Statistical analysis

Descriptive statistics were reported for each time point. Kaplan Meier and life-table survival analysis was performed by a statistician (PW) using the Statistical Package for the Social Sciences (IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY). Differences between groups due to gender and age were assessed for significance using Mantel-Cox log rank test. 70 years of age was used as a cut off for comparison to allow equivalent group size (initially planned as 65 years, but changed due to group asymmetry). Failure of the prosthesis was defined by revision, or need for revision.

3. Results

3.1 Early Complication

Two patients developed a superficial wound infection which was successfully treated with oral antibiotics. One patient had delayed wound healing in the absence of infection. There were no deep surgical site infections. One patient developed a below-knee deep vein thrombosis without further complication.

3.2 All case survivorship

Mean patient follow up was 14.8 years (SD 6.6 years, range 11 months - 28.3 years), and is shown in Figure 2. No patients were lost to follow-up. At final scoring in October 2015, 74 knees (64 patients) (91%) had died. Of these, 58 knees were unrevised and had not failed by the time of death, meaning 78% of patients died with a functioning prosthesis in situ. Of the surviving 7 knees (6 patients), 3 knees (2 patients) had undergone revision. Mean time to death was 14.1 years (range 0.9 – 28.3yrs). Kaplan-Meier implant survival curve is shown in Figure 3, and life table analysis in Table 1. Estimated 25 year survivorship is 68%.

3.3 Effect of age on survivorship

Thirty seven knees (33 patients) were <70 years of age at time of index procedure. Of these, 31 knees (84%) had died at time of final review. Twenty three knees (74%) died with a functioning prosthesis in situ. Mean time to death was 17.8 years.

44 knees (38 patients) were ≥ 70 years of age at time of index procedure. Of these 43 knees (98%) had died at time of final review. 35 knees (81%) died with a functioning prosthesis in situ. Mean time to death was 10.6 years.

Kaplan Meier plot for patients <70 years and ≥70 years are shown in figure 4. There was no difference in the survivorship curves when compared by age (p=0.743). However the small number of events (revisions/failures), and high degree of censorship due to death may make this comparison unreliable.

3.4 Effect of gender on survivorship

No difference was demonstrated when male and female patients were compared (p=0.231), however small numbers of failures and asymmetry in group size may affect this comparison.

3.5 Revision

Nineteen patients (23.4%) underwent revision. There were no additional failures that were awaiting revision. Reasons for revision are shown in table 2. Mean time to revision for aseptic loosening and progression of arthritis were 7.2 and 10.1 years respectively. Seventeen (89%) of the revisions were to a primary total knee replacement, one to a revision (stemmed) prosthesis, and one unknown as it was performed out of area.

3.6 Outcome Scores

Outcome scores increased until 10 years post operatively, and then demonstrated a gentle decline thereafter. Scores are summarised in table 3, and long term Bristol Knee, OKS and WOMAC scores displayed in Figures 5-7.

4. Discussion

The benefits of unicompartmental knee replacement to both patient and healthcare provider are becoming increasingly well recognised [1-8, 34]. Subsequently there has been a subtle increase in uptake with 10% of knee arthroplasty performed in the UK now partial joint replacement [9]. Studies reporting mid- to long term survivorship and patient outcomes for fixed-bearing *medial* replacement are plentiful, with survivorship of 85-93% [30, 35-41] and 74-91% [39, 41-43] reported at 15 and 20 years respectively. O'Rourke and Steele et al are the only authors to publish series estimating 25 year survivorship of 72 and 80% [42, 44], though O'Rourke's series comprised a mixed cohort of both medial and lateral replacements, and Steele's series reported a cohort of knees that had already survived 10 years, thus excluding early revision. With *lateral* compartment replacement constituting between 5 and 10% of partial joint replacement by volume [10-12], papers reporting long term follow-up for lateral prostheses only are small in series size and few in number.

This study constitutes almost a life time follow up of patients who underwent some of the first lateral joint replacements available, from a centre experienced in partial knee arthroplasty. We estimate survivorship of 72% at 15 years, and 68% at 20 and 25 years. This presents a slightly lower survivorship when compared with the currently available long term cohorts (Table 4). The series of 29 knees published by Pennington et al [10] with no revisions at 15 years remains the best performing cohort to date, though further follow up data has not been reported. Heyse and Lustig et al [45, 46] have both estimated survivorship at 92% at 15 years in a series of approximately 50 knees. The results of the latter cohort have been updated in Deroche et al's recent paper to 82% at 15 years, and 79% at 20 years [24]. Previous reporting of lateral Sleds from our unit estimated 15 year survivorship at 75%, though only ten knees remained at risk for analysis at this time point [47]. It would appear then that a survivorship of approximately 70% at 25 years is consistent across the limited cohort literature for both lateral and medial compartment replacement.

Registry data for long term survivorship of unicompartmental replacement continue to report combined cohorts of both medial and lateral replacement, and fixed and mobile bearing designs. Importantly, it has been demonstrated that registry data often underestimate survivorship of prostheses when compared with cohort studies from experienced centres [30, 41]. The differences in reporting extend beyond the scope of this paper, but reporter bias and revision thresholds are commonly cited explanations for the discrepancy [48]. Direct comparison with our results is therefore difficult, however the UK NJR currently estimates survivorship of UKA at 82-87% at 14 years, and Finish registry data estimate 77% at 15 years, 72% at 20 years, and 70% at 25 years [41]. The latter estimate is clearly more aligned to our findings, and likely represent similar reporting of an early prostheses which inevitably had problems that newer implants have learnt from, thus improving the results in contemporary literature with mid-term follow up [30]. The causality for revision in our cohort would also support this. We observed two femoral implant fractures resulting in early revision, and aseptic loosening constituting 16% of revision at a relatively early mean time point of 7.2 years. For implants without early problems, progression of arthritis in a remaining compartment was the most common cause for later revision, and this is frequently quoted as the commonest cause for revision in UKA, particularly in the lateral compartment [31]. 50% of progression in our cohort was in the patellofemoral joint alone, and 50% in both the patellofemoral and medial compartments. It has been established that careful attention to maintaining an overall valgus alignment is paramount in ensuring a successful outcome with lateral UKA [49], and it is possible that an early tendency to overstuff the naturally looser lateral compartment when the technique was being established may explain our higher revision rate due to medial arthritis progression. The link with development of subsequent patellofemoral arthritis in isolation however is more difficult to explain, and is likely to be reflective of the underlying valgus alignment associated with lateral compartment OA. We unfortunately do not have long leg alignment radiographs dating back to the start of the study, and so these potential explanations remain hypothetical.

When analysis was performed by age, we found no difference in survivorship for younger patients versus older patients, when using 70 years as the division for the groups. Joint registry data would suggest that the younger patients have an inferior survivorship profile, and this is particularly profound for patients under 60 years of age. The survivorship then becomes progressively better the more elderly the cohort [9]. The discrepancy with our findings may be explained by the small numbers of revisions in either group resulting in an underpowered comparison, or perhaps that there is in fact little difference if 70 years is used to define the groups. What is interesting however, is that when the likelihood of a patient dying before their implant needs revising is considered, 81% of patients in the older group died prior to revision (at a mean of 10.1 years) compared with 74% in the younger group (at a mean of 17.8 years). This would therefore support that unicompartmental replacement may be a good operation for the elderly, providing the short term peri-operative benefits established by Liddle et al [1], with 8 out of 10 patients not living long enough to entertain the concerns of higher revision rate when compared to total knee replacement. The proportion of patients dying prior to revision is likely to be higher now with the use of contemporary implants, and so this effect may be greater than we have found.

Patient reported outcome scores appeared to steadily drop following the ten year interval. This is similar to the data of other long term series, however direct comparison is difficult due to the heterogeneity in scoring systems reported [10, 21, 23, 24, 28, 45]. Reporting of long term functional outcome in this cohort of patients is difficult, as patients with surviving protheses in situ are inevitably elderly, and many have confounding associated comorbidities. The negative correlation of outcome scores with increasing age has been previously reported upon by Bremner-Smith et al [50], and so the 'decay' in PROMs observed appears to be not unusual. The number of patients in the later years of follow up are also inevitably reduced, and this is likely to be an limitation of all long term series following an increasingly elderly population.

This study has further limitations. With a mean age at index procedure of 70 years, it represents a relatively elderly population when compared to current practice (63.7 years in the UK NJR [9]). We therefore experienced a high censorship due to death, and thus small numbers for analysis in the tail for both Kaplan Meier and functional outcome analysis. There were also too few failures during the patients' lifetimes to allow calculation of a median survival for the prosthesis, and to allow meaningful comparison by age or gender. However, despite these limitations, it does constitute one of the few long-term studies within the literature, with zero loss to follow up, and therefore it is important that it is reported.

5. Conclusion

Fixed bearing lateral unicompartmental replacement demonstrates good long term survivorship, particularly for the elderly patient, whereby the implant will out survive the patient in the majority of cases. In reporting one of the earliest prostheses available, some inevitable implant complications are reported which should have been eliminated in contemporary designs. Where revision is necessary, this is possible using primary prostheses in the majority of cases.

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Tables

Interval Start Time	Number Entering Interval	Number Withdraw-ing during Interval	Number Exposed to Risk	Number of Terminal Events	Cumulative Proportion Surviving at End of Interval
0	81	1	80.5	0	1.00
5	73	0	73.0	2	0.92
10	50	6	47.0	2	0.77
15	29	5	26.5	1	0.72
20	14	2	13.0	0	0.68
25	6	3	4.5	0	0.68
28	1	1	0.5	0	0.68

Table 1 - Life table survivorship for all cases

Peri-prosthetic fracture	1	5%
Implant fracture	2	11%
Unknown	3	16%
Aseptic loosening	3	16%
Progressive arthritis	10 (5 Patellofemoral only, 5 global OA)	53%

Table 2 - Reasons for revision

	Pre-op	10 years	15 years	20 years	25 years
Number scored	62	22	8	4	4
Mean Bristol Knee Score (Best 100)	52.7	84.5	76.6	74	90
Mean OKS (Best 48)	N/A	35.3	27.3	21	37.7
WOMAC (Best 12)	N/A	23.2	30.3	34	18.75

Table 3 - Summary outcome scores

Study	ref.	Year	n	10 year	15 year	20 year	25 year
Ashraf		2002	88	83%	75%		
Pennington		2006	29		100%		
Argenson		2008	40	92%*			
Lustig		2009	60	98%			
Lustig		2011	54	98%			
Heyse		2012	50	92%	92%		
Lustig		2014	54	94%	91%		
Deroche		2019	54		82%	79%	
Murray		2020	81	77%	72%%	68%	68%

*mixed cohort of different prostheses

Table 4 - Fixed-bearing, lateral unicompartmental series with 10 years follow up or greater

Figures

Figure 1 - St Georg Sled prosthesis

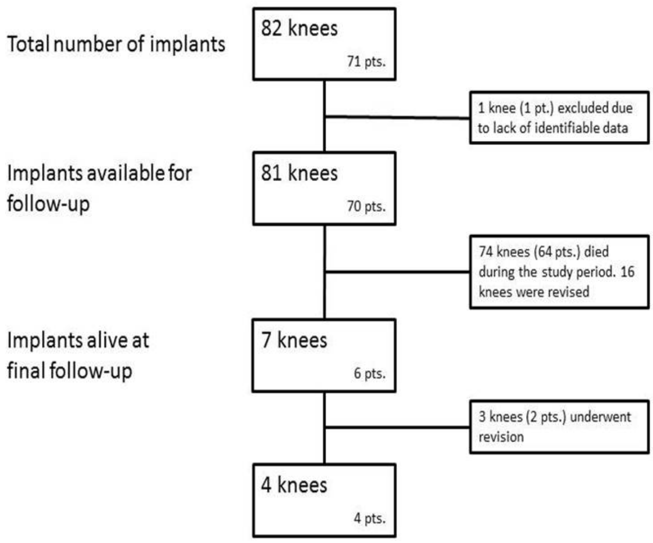

Figure 2 - Follow-up of patients

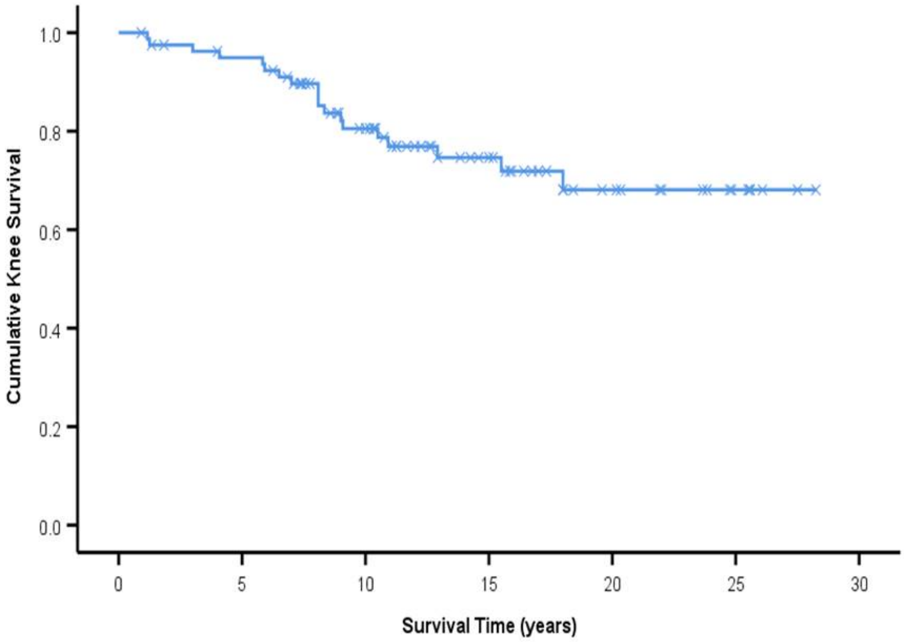

Figure 3 - Kaplan-Meier survivorship curve for all causes of failure

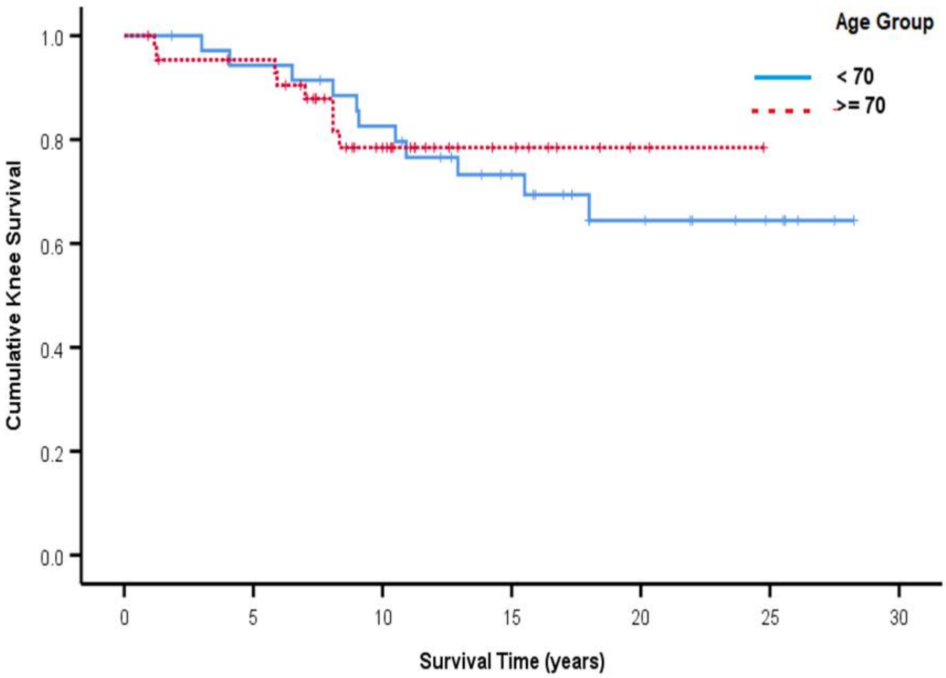

Figure 4 - Kaplan-Meier survivorship curve for age <70 years and ≥70 years (p=0.743)

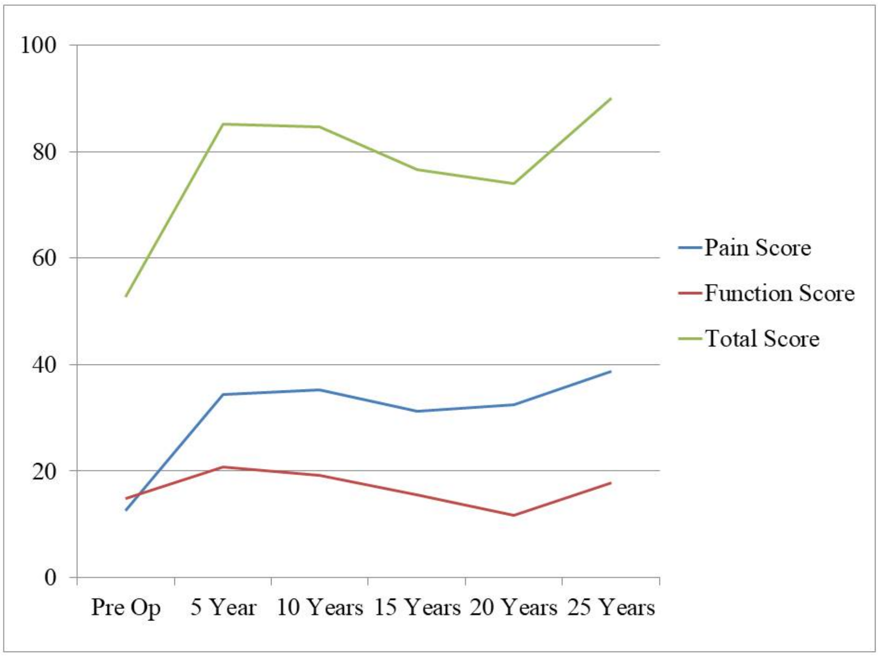

Figure 5 - Bristol knee scores

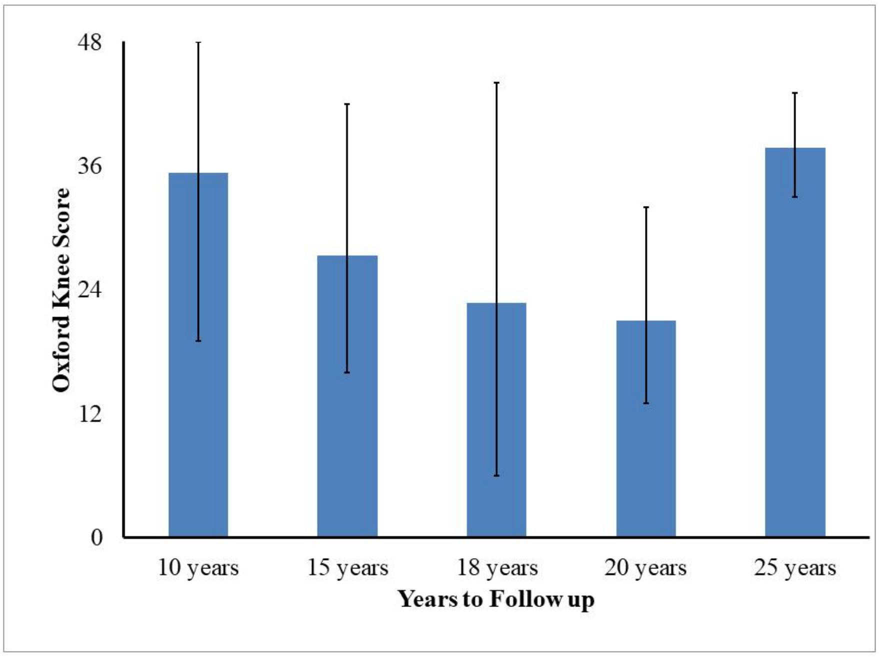

Figure 6 - Oxford Knee Scores (error bars represent range)

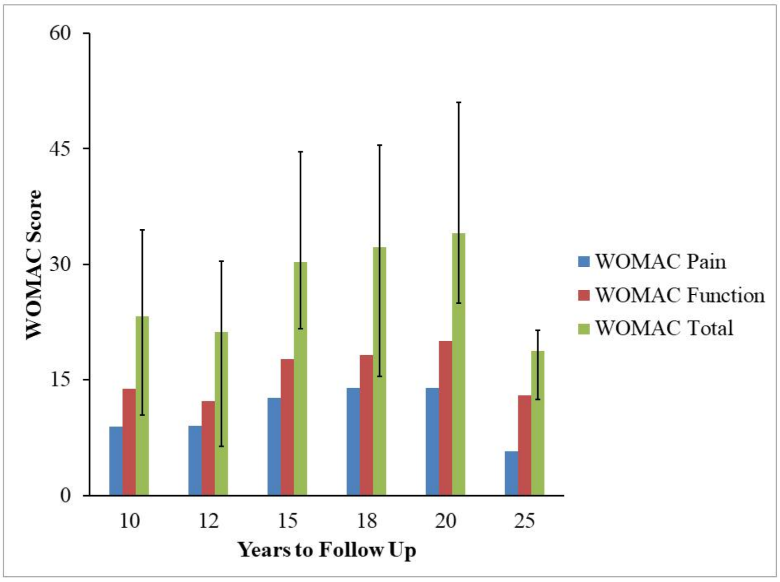

Figure 7 - WOMAC scores (error bars represent range)

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Figure legends

Figure 1 - St Georg Sled prosthesis

Figure 2 - Follow-up of patients

Figure 3 - Kaplan-Meier survivorship curve for all causes of failure

Figure 4 - Kaplan-Meier survivorship curve for age <70 years and ≥70 years ($p=0.743$)

Figure 5 - Bristol knee scores

Figure 6 - Oxford Knee Scores (error bars represent range)

Figure 7 - WOMAC scores (error bars represent range)

Table legends

Table 1 - Life table survivorship for all cases

Table 2 - Reasons for revision

Table 3 - Summary outcome scores

Table 4 - Fixed-bearing, lateral unicompartmental series with 10 years follow up or greater