St Georg Sled medial unicompartmental arthroplasty; survivorship analysis and function at 20 years follow-up

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Abstract

Purpose: The peri-operative and short term benefits of unicompartmental knee arthroplasty (UKA) are well supported in the literature. However, there remains concern regarding the higher revision rate when compared with total knee replacement. This manuscript reports the functional outcome and survivorship of a large series of fixed bearing, medial unicompartmental replacements (St Georg Sled), with a minimum of 20 years follow up.

Methods: Between 1974 and 1994, 399 patients (496 knees) underwent a medial fixed-bearing UKA. Prospective data was collected pre-operatively and at regular intervals post-operatively using the Bristol Knee Score (BKS), Oxford Knee (OKS) and Western Ontario MacMaster (WOMAC) scores. Kaplan Meier survival analysis was used to determine survivorship, with revision or need for revision as end point, and differences assessed using Mantel-Cox log rank test.

Results: Functional knee scores improved post-operatively, but demonstrated a slight decline from 10 years of follow up onwards. Survivorship is estimated as 86% at 10 years, 80% at 15 years, and 78% at 20 years. Sixty knees were revised, with progression of disease in another compartment the commonest reason. Eighty eight percent were revised using a primary prosthesis. For patients over the age of 65 years at the time of index procedure, 93% died with a functioning prosthesis in situ.

Conclusion: Medial UKA demonstrates good long term function and survivorship, and represents an excellent surgical option for patients aged over 65 years of age, where few patients will require a revision procedure.

Keywords

Unicompartmental knee arthroplasty; medial; fixed bearing, all-polyethelene; St Georg Sled; outcome

Level of Evidence

IV

Introduction

The benefits of unicompartmental knee arthroplasty (UKA) over total knee arthroplasty (TKA) are well supported in the literature. Advantages include shorter operative time, less requirement for blood transfusion, lower risk of thromboembolic events, lower mortality at all time points [28, 33], and better early patient reported outcomes scores [13, 30, 31, 34]. With shorter hospital stay and lower readmission rate [44], UKA is also an increasingly attractive economic proposition for the publicly funded healthcare system, with savings of approximately £1500 per 70 year old patient [13, 17, 43, 51, 58]. Despite these advantages, concerns remain regarding the higher published revision rates for UKA [23, 55]. Ten year registry data report survivorship between 80 and 89% [2, 3, 9, 55], with the UK National Joint Registry estimating survivorship of 83% at 15 years [1]. Cohort studies reporting on medial UKA alone estimate survivorship between 74 and 98% at the same follow up interval however [4-6, 14, 16, 21, 24, 25, 29, 35-38, 41, 45, 48, 49, 53, 56, 57, 59-61], with 20 year survivorship estimated between 74 and 90% for fixed bearing constructs [7, 24, 42, 52, 54]. The discrepancy between registry and cohort data is acknowledged in the literature [23, 55], and proposed rationale include a critical procedure volume [10, 11, 47] and lower revision threshold for UKA compared to TKA [12, 27]. To better establish the true survivorship of partial tibiofemoral knee replacement, it is important that long term cohorts performed in high volume and experienced units are reported transparently.

The St Georg Sled UKA was one of the first widely implanted prothesis, and an iteration is still manufactured today (Endo-Model® sled). It was used in our centre between 1974 and 1994, and this paper reports the long term survivorship and functional outcome of this implant, with the hypothesis that the long term outcomes are better than those reported in registry data for prostheses of the same era.

Methods

Participant details

Between November 1974 and December 1994, data was collected prospectively from 399 patients (496 knees). All operations were performed by 6 surgeons or their trainees. Fourteen patients (17 knees) had no clinical data recorded, and were excluded from the cohort, leaving 385 patients with a total of 479 medial unicompartmental arthroplasties. Ninety four patients underwent staged bilateral procedures. Mean patient age at time of index procedure was 72 years (SD 8.3 years). Two hundred and thirty eight (62%) patients were female and 147 male.

Indication for surgery was anteromedial arthritis, less than 15^{o} of fixed-flexion deformity, and less than 15^{o} of correctable varus alignment in the coronal plane with intact ligaments. ACL deficiency was a contraindication. Asymptomatic joint space narrowing or the presence of osteophytes in either of the other two compartments was not considered an absolute contraindication [20].

Prospective data was collected in clinic on all patients pre- and post-operatively at 1, 2, 5, 8, and 10 years, and then at regular 5 year intervals whilst the patient remained alive. Patients were initially scored using only the Bristol Knee Score (BKS), which provides categorical values for pain, general function and knee function [39]. 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 patient reporting outcome measures were developed, and so the Oxford Knee (OKS) and Western Ontario MacMaster (WOMAC) scores are reported in addition post-operatively from 1999. Short-leg anteroposterior, lateral and patella skyline radiographs were taken at each follow-up to monitor for signs of disease progression in the remaining compartments, and signs of prosthetic failure. Patients who were too frail to, or declined face-to-face follow-up, completed either postal questionnaire or telephone interview conducted by a trained research nurse or orthopaedic surgeon. Revision or necessary revision of the prosthesis for any reason was used to define 'failure' for the survivorship analysis

Prosthesis and surgical technique

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

All Sleds were implanted using a limited medial parapatellar approach. The proximal tibial resection was performed using a simple extra-articular medullary alignment jig. The tibial cut was marked and cut freehand. Femoral preparation was performed using a series of templates which allowed a decision to be made regarding size and placement of the implant - this was based upon coverage and shape match of the curvature of the selected size relative to the distal femur. Femoral peg holes were marked using the templates. A saw or curette was then used to denude any remaining damaged cartilage from the medial condyle, and lug holes drilled. Balancing of the knee was performed using trial spacers, similar to standard contemporary techniques.

Ethical approval for the study was granted by the SouthWest Regional Ethics Committee (ref: 09/H0206/72).

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. Gross differences in age were assessed using 65 years as a comparator. Failure of the prosthesis was defined as revision, or need for revision. Simple regression analysis was performed to assess the contribution of age on revision rate, and an alpha value of 0.05 utilised to establish significance.

Results

Gross Survivorship

Patient follow up is shown in Figure 2, and ranged between 6 months and 34 years (mean 13.3 years). At final scoring in October 2015, 391 knees had died (305 patients), and of these 357 knees were unrevised. Three knees in addition had failed and not been revised by time of death, meaning that 91% of patients that died had a functioning prosthesis in situ at time of death. Mean time to death was 12.7 years (range 9 months – 30 years). Of the surviving 88 knees (77 patients), 26 knees had undergone revision. Sixteen knees (3%) were lost to follow up.

Survivorship is estimated as 86% at 10 years, 80% at 15 years, and 78% at 20 years. An estimate is available for the 25 year time point of 73%, however only 28 patients entered this interval and so this statistic may be unreliable. Kaplan Meier implant survival curve for the whole cohort is shown in Figure 3, and life table analysis in Table 1.

Effect of age

One hundred and thirty knees (105 patients) were <65 years of age at time of index procedure. Of these 73 knees (56%) had died at time of final review. 37 knees (51%) died with a functioning prosthesis in situ. Mean time to death was 15 years.

Three hundred and forty nine knees (280 patients) were ≥ 65 years of age at time of index procedure. Of these 320 knees (92%) had died at time of final review. Two hundred and ninety eight knees (93%) died with a functioning prosthesis in situ. Mean time to death was 12.1 years.

Kaplan Meier analysis for patients under and over 65 years respectively demonstrates the curves to be significantly different (Figure 4, $p<0.001$). Revision rate for 10 year age groups is shown in Figure 5, and demonstrates a downward trend with R2 of 0.86.

Effect of gender

There was no difference in survival identified for gender even when stratified for age.

Revision

Sixty patients (12.5%) underwent revision. There were three 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 10.1 and 8.3 years respectively. Forty seven (78%) of the revisions were to a primary knee replacement, 7 (12%) to a revision prosthesis, and 6 (10%) to another unicompartmental replacement. The proportion of primary replacements requiring a stemmed tibial prosthesis was not available.

Outcome scores

BKS demonstrated a gentle decline after 5 years, OKS after 10 years, and WOMAC remained constant throughout the follow up interval. Long term Bristol Knee, OKS and WOMAC scores are displayed in Table 3.

Discussion

This study reports survivorship of the medial St Georg Sled prosthesis as 86% at 10 years, 80% at 15 years, and 78% at 20 years. This is better than reported registry studies of the same era [23].

Previous series reporting on mid-to-long term survivorship and outcome of fixed bearing medial UKA have been published (Table 4). Estimates of 10 year survivorship range between 74% and 98%, with some of this variation depending upon whether survivorship endpoint is defined as revision or failure of the implant (including ongoing pain). [4, 6, 16, 24, 25, 35, 48, 49, 59, 60]. The earliest series reporting an all-polyethylene tibial component was by Ansari et al [6], who reported the 10 year results of this cohort. They estimated 10 year survivorship at 87%, however this figure reduced to 74% if knees that were considered to have failed due to pain were included. Ansari's paper constituted the largest series prior to this paper, though Winnock et al [59] have recently published a contemporary series of 460 knees using the ZUK implant (Zimmer Biomet) with estimated 10 year survivorship of 94.2%. Two large multi-centre series also exist, both estimating survivorship at 83.7% [18, 49], however both these studies include multiple different implants.

Series with longer term follow up are fewer in number, with five studies reporting results at 20 years, and one at 25 years [7, 42, 52, 54]. Tabor et al [54] report a series of 100 fixed bearing knees from North America, with 20 year survivorship estimated at 80%. They report Knee Society knee and function scores of 89 and 73 points respectively at final follow up. In 2013, Argenson et al published an update of their original series of 160 metal-backed, fixed-bearing Miller Galante implants [8], estimating survivorship of 74% at 20 years [7]. They report knee and function scores of 91 and 88 points respectively in 70 surviving knees. Steele et al previously reported a reduced cohort of St Georg Sleds from our centre, with 20 and 25 year survivorship of 86% and 80% respectively. They report Bristol Knee Scores of 86 out of 100 at final follow up [52]. Whilst these results appear excellent, this series may misrepresent the true long-term outcome as it contains only implants that had already survived 10 years, excluding implants that had failed prior to this time point. This series, reporting the full cohort therefore presents a fairer reflection of the outcome of this prosthesis. The remaining series quoting 20 year survivorship was published by Parratte et al in 2012 [42]. They retrospectively compared a cohort of 79 Miller Galante fixed bearing prostheses to a cohort of 77 mobile bearing Oxford implants. The authors report no difference in survivorship at 20 years, with 83% of the Miller Galante implants and 80% of the Oxford prostheses estimated to survive to this time interval. Knee Society Scores were comparable for the fixed bearing and mobile implants. Whether fixed or mobile bearing systems have better outcome continues to be widely debated, and is beyond the scope of this paper. Still relatively few studies exist that compare the philosophies directly [19, 22, 26, 32, 38], with meta-analysis of the available evidence concluding no difference in survivorship or functional outcomes [50]. A properly conducted randomised controlled trial is still needed to answer this question definitively.

Registry data reporting the long term survivorship of UKA is growing by the year, and allows some comparison amongst implants and between fixed and mobile bearing platforms. However, this remains population observational data, and it has been demonstrated that registries often underestimate survivorship of prostheses when compared with studies from experienced centres [23, 55]. The UK and Australian Joint Registries estimate survivorship of cemented fixed bearing UKA at 15 years at 82% and 78% respectively [1, 9]. Finnish registry estimates are slightly lower at 77% at 15 years, 72% at 20 years, and 70% at 25 years [23]. These Finnish figures are comparable to the survivorship of this cohort, and therefore likely represent the realistic outcomes observed when using early prostheses, which inevitably had some early problems.

Outcome scores for this cohort demonstrated an improvement post operatively, which was maintained to approximately 10 years. There was a decrease in the Oxford Knee and Bristol Knee Scores from this time point onwards, with maintenance largely of WOMAC scores to 20 year follow up. Oxford scores in the high twenties are low by modern implant standards [13], and comparison with older implants is difficult due to the heterogeneity of outcome scores used. The decrease in scores from 10 years onwards may be implant related, but may reflect the relatively older age of this cohort, with medical comorbidity confounding the results. Additionally, the Bristol Knee Score used in the early part of this study predated the inception of modern day patient reported outcome scores, and although useful to show trends, was not ever independently validated, which is clearly a shortfall in its use. Despite these limitations, these scores represent a valuable early attempt in objectifying the outcome of the implant.

In this cohort, sixty patients underwent revision of their implant, with the majority occurring within the first 10 years. This pattern is similar to that reported by Price et al [46] and may represent early failure due to inappropriate patient selection, technical shortcomings, or implant related failures of early designs. It may also represent a lower likelihood of revision due to increasing patient age and comorbidity, although our series should mitigate for this having used failure rather than revision as an end point. For those who required revision, only 12% needed a revision prosthesis. Progression of arthritis in another compartment constituted a third of the revisions, with aseptic loosening, polyethylene wear and component fracture following in descending order. Progression of arthritis is frequently cited as the commonest cause for revision in unicompartmental replacement [6-8, 18, 24, 40, 42, 46, 52, 59], with component fracture now being extremely rare. Six of our seven failed components were on the femoral side, at a mean time of 9.5 years. Subsequent modification of the femoral component in 1988 from a keel to peg-based fixation (but with preservation of bearing design) prevented any further prosthetic fractures.

When Kaplan-Meier survivorship analysis was performed to allow comparison by age, a survivorship advantage for patients older than 65 years at time of implantation (Figure 4) was demonstrated. This is supported by Joint Registry data, which report inferior survivorship with younger age, and an overall revision rate of approximately 25% at 15 years in patients under the age of 55 (survivorship for fixed bearing prostheses is closer to 85% however for fixed bearing prostheses)[1]. This higher revision rate for younger patients has also been demonstrated in our regression analysis, which suggests the chance of revision at any time point in a 50 year old to be in the order of 30%. This decreases with age in a linear fashion, with approximately a 5% chance of revision if over 70 years of age at time of surgery (Figure 5). This relationship is clearly dependent on how long patients of different ages are expected to survive for. In an attempt to account for this, the proportion of patients who die with a functioning, non-revised implant in situ are also reported - a 'pragmatic survivorship'. For patients over the age of 65 years, 93% will die prior to their implant failing, resulting in a 'pragmatic revision rate' of 7% for this age group. However, it is acknowledged that the revision threshold in more elderly patients is often higher, as the decision to revise becomes a significant undertaking in terms of surgical risk. This will then inevitably reduce the revision rate with increasing age. One method by which this is often mitigated for in reporting survivorship is by using a lower patient outcome score as a revision threshold. Whilst this may be possible, increasing comorbidity with ageing has been shown to negatively influence functional scoring [15], and so this method for defining a failing implant may not be as reliable when used in elderly patients. Despite the apparent high revision rate in this series then, it would seem that unicompartmental replacement remains an excellent option for the elderly patient, with the vast majority of implants out-surviving their host

This study has limitations in addition to those already mentioned regarding outcome scores. The relatively elderly population resulted in a high degree of censorship of data due to death, and thus small numbers for analysis in the tail for Kaplan Meier analysis. For the surviving patients, increasing comorbidity and geographical mobility over the long follow up period also contributed to some loss to follow up, though this was only 3% overall. In addition, there were too few failures of the implant to allow for a meaningful estimate of median prosthesis survival. This may also have prevented a meaningful comparison for gender, with the study being effectively underpowered to identify a difference associated with this variable. A further limitation is the change in femoral component design from a keel to peg based fixation during the latter years of the study. This change means that the cohort is not entirely homogenous, but unfortunately due to the historical nature of the cohort we were not able to determine which patients had which design, and therefore included all in the cohort and reported the results transparently. Finally it must be acknowledged that the results of this cohort cannot reliably be generalised to modern day implants. Lessons have been learnt in implant design and the measurement of outcomes, and modern day implants are expected to significantly outperform early cohorts. However, the message that unicompartmental replacement represents a good option for the more elderly patient with a very low pragmatic revision rate is still relevant, and should be considered in contemporary practice.

Conclusion

Fixed bearing medial unicompartmental replacement is a good procedure, particularly for the elderly patient, whereby the implant will out-survive its host in the majority patients. The long term survivorship of this implant is better than that stated in registry studies from the same era. Where revision is necessary, only a small proportion will require revision implants.

Tables

Interval Start Time	Number Entering Interval	Number Withdrawing during Interval	Number Exposed to Risk	Number of Terminal Events	Proportion Terminating	Proportion Surviving	Cumulative Proportion Surviving at End of Interval
0	479	44	457	14	.03	.97	.97
5	421	98	372	20	.05	.95	.92
10	303	110	248	16	.06	.94	.86
15	177	55	150	10	.07	.93	.80
20	112	82	71	2	.03	.97	.78
25	28	25	15	1	.06	.94	.73

Table 1 – Life table for all cases

	n	% of revisions	% male	Mean time to revision (years)	Range
Infection	1	2%	100%	10.5	
Loose cement	1	2%	0%	12.0	
Unexplained pain	1	2%	0%	4.1	
Periprosthetic fracture	2	3%	50%	9.6	9.1-10.2
Unknown	2	3%	0%	12.2	7.2-17.2
Component fracture (6 femoral component)	7	12%	71%	9.5	2.2-19.2
Polyethylene wear	10	17%	30%	11.4	5.7-16.6
Aseptic loosening	14	23%	50%	10.1	1.5-27.2
Progression of OA	22	37%	45%	8.3	0.5-20.0

Table 2 – Reasons for revision

	Pre-op	10 years	15 years	20 years
Mean Bristol Knee Score (Best 100)	54.6 (SD11.9)	85.1 (SD 14.8)	78.5 (SD19.8)	82.3 (SD14.7)
Mean OKS (Best 48)	N/A	38.7 (SD9.7)	32.2 (SD11.4)	29.5 (SD10.3)
Mean WOMAC (Best 12)	N/A	16.3 (SD9.3)	24.1 (SD5.3)	29.2 (SD10.1)

Table 3 - Summary of outcome scores

Study	ref.	Year	n	Fixed / mobile	10 year	15 year	20 year	25 year
Ansari	[6]	1997	461	Fixed	87% (74%)			
Ackroyd	[4]	2002	408	Fixed	88% (79%)			
Yang	[60]	2003	113	Fixed	95%	85%		
Tabor	[54]	2005	100	Fixed	90%	86%	80%	
Steele	[52]	2006	203	Fixed		92%	86%	80%
Parratte	[42]	2012	79	Fixed			83%	
Foran	[24]	2013	62	Fixed	98%	93%	90%	
Sebilo	[49]	2013	720*	Fixed	84%			
Argenson	[7]	2013	160	Fixed		83%	74%	
Chatellard	[18]	2013	559*	Fixed	84%			
Confalonieri	[19]	2014	53	Fixed	91%			
Schleuter-Brust	[48]	2014	234	Fixed	95%			
Bruni	[16]	2016	237	Fixed	88%			
Forster-Horvath	[25]	2016	270	Fixed	91%			
Kim	[29]	2018	106	Fixed	93% (89%)			
Neufeld	[38]	2018	68	Fixed	91%			
Winnock	[59]	2018	460	Fixed	94%			
Porteous		2021	479	Fixed	86%	80%	76%	73%

* denotes multi-centre, multiple prostheses. Numbers in brackets represent rate for failure of prosthesis, in addition to revision

Table 4 - Long term cohort series of medial UKA to date

Figures

Figure 1 - St Georg sled prosthesis

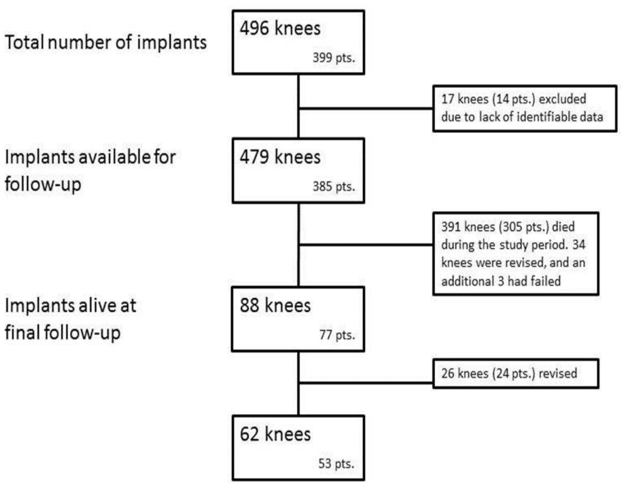

Figure 2 - Patient follow up

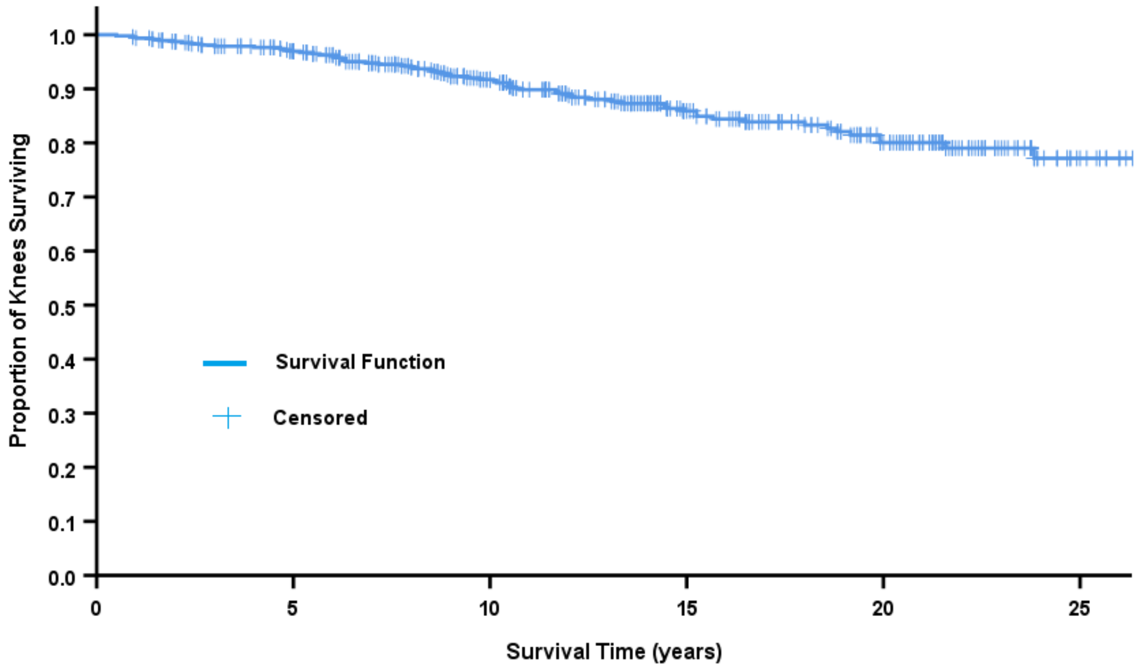

Figure 3 - Kaplan-Meier survivorship curve for all cases and all causes of failure

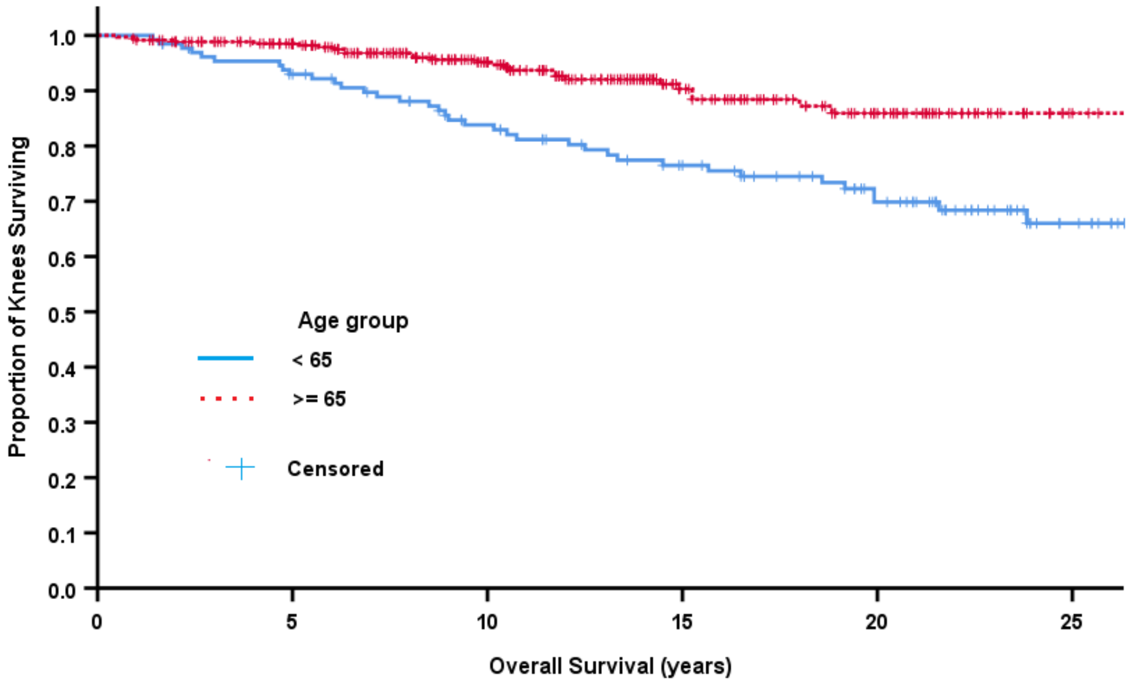

Figure 4 - Kaplan-Meier survivorship curve for age <65 years and ≥65 years ($p<0.001$)

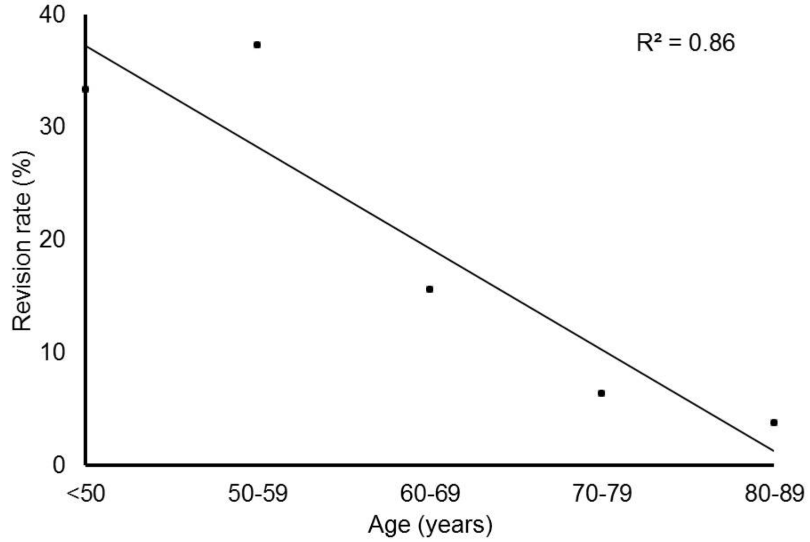

Figure 5 - Revision rate for 10 year age groups

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