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ORIGINAL STUDY

5 Year Outcomes and Survivorship of the Triathlon Total Knee Replacement: a Cohort Study

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The aim of this study was to determine outcomes and survivorship of the Triathlon knee replacement up to 5 years post-operation. A cohort of 266 patients receiving a Triathlon knee replacement were assessed before surgery and at 3 months, 1 year, 2 years, 3 years and 5 years post-operation. Assessments included patient-reported outcome measures, American Knee Society Score, complications and survivorship. The largest improvements in pain, function, stiffness and knee-related quality of life occurred in the first 3 months post-operation. Further smaller improvements were reported between 3 and 12 months post-operation, and then a plateauing of outcomes was observed up to 5 years. A high percentage of patients (86%) were satisfied with their outcome at 5 years. Survivorship with revision as the endpoint was 96.6% (95% CI 93.2-98.1%) at 5 years post-operation. In conclusion, this study observed good mid-term patient outcomes and survivorship of the Triathlon knee replacement.

Keywords : Total knee replacement; Patient Reported Outcomes; Satisfaction; Pain; Survivorship

INTRODUCTION

Primary total knee replacement (TKR) is one of the most common elective surgical procedures, and the need for the surgery is predicted to grow over the coming decades *(20)*. New prosthetic designs are continually introduced into the market to meet the growing demand for TKR *(23)*. With the vast range of implants available, it is essential that research evaluates the different prosthetic designs to provide an evidence-base to aid orthopaedic surgeons with decisions around choice of implant. Evaluation of the results of different knee prostheses should be multidimensional to capture both clinical outcomes and patient-reported outcomes. Survivorship, complications, alignment, pain, function and health-related quality of life are all important outcomes after TKR. There is also a need for longitudinal studies, as this allows for the charting of recovery patterns and outcome trajectory after surgery.

Since 2010, the Triathlon knee replacement has been the third most commonly used total condylar

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knee prosthesis in the UK, and accounted for 13% of TKRs performed in 2013 in England, Wales and Northern Ireland *(23)*. The Triathlon prosthesis is designed to provide patients with more natural knee motion and the potential for greater implant longevity *(31)*. Previous research has compared outcomes after the Triathlon knee replacement to other prostheses and found that the Triathlon results in better outcomes than the Kinemax *(7, 10)* and Duracon knee *(22, 25)*. Data from the National Joint Registry demonstrates that the Triathlon prosthesis has excellent survivorship, with a revision rate for all causes of only 1.99% at 5 years, one of the lowest revision rates of the leading implants *(23)*. Other studies have investigated outcomes such as range of motion and complications of the Triathlon knee replacement *(9, 13, 14)*. However, these more objective outcomes fail to evaluate the success of surgery from the perspective of the patient. The aim of this prospective cohort study was to determine patient-reported outcomes, clinical outcomes and survivorship of the Triathlon knee replacement up to 5 years post-operation.

PATIENTS AND METHODS

Recruitment

Between October 2006 and October 2009, patients attending a pre-operative assessment clinic at a large elective orthopaedic centre were approached about the study. Eligibility criteria included being listed for a primary Triathlon knee replacement for an indication of osteoarthritis. Patients undergoing revision surgery or that were unable or unwilling to provide informed consent where excluded. Participants provided informed written consent. Ethical approval was obtained from the local Research Ethics Committee (Reference : 06/Q2002/80).

Assessment times

Patients were assessed pre-operatively and then at the following post-operative intervals : three months, one year, two years, three years and five years. Assessments involved a combination of self-report questionnaires, clinical examinations and medical records review.

Patient-reported outcome measures

Western Ontario McMasters University Osteoarthritis Index (WOMAC) *(4)*: assesses knee pain severity during five activities, extent of functional limitations when performing 17 tasks, and degree of stiffness in the morning and later in the day. Total scores for each of the scales were transformed to a 0-100 scale (worst to best).

Knee Injury and Osteoarthritis outcome score (KOOS) Knee-related Quality of Life Scale *(26)* : assesses the extent to which patients are aware of their knee problems and how much they impact on their daily life, with a total score from 0-100 (worst-best).

UCLA Activity Score *(1)* : assesses activity level from wholly inactive and dependent on others to regular participation in high impact sports, based on a scale from 0-10 (low to high activity level).

The Self-Administered Patient Satisfaction Scale for Primary Hip and Knee Arthroplasty *(21)* : assesses satisfaction with overall outcome, pain relief, ability to perform daily activities, and ability to participate in leisure activities. Responses are on a 4-point scale from very satisfied to very dissatisfied, with a global satisfaction scale of 0-100 (worst to best). In addition, patients were asked at each post-operative assessment time whether or not they regretted having their knee surgery.

Kneeling : At each assessment time, patients were asked if they had tried kneeling, and if so, how much difficulty they experienced when kneeling.

American Knee Society Score (AKSS)

The AKSS *(16)* was collected pre-operatively and at 3 months, 1 year, 3 years and 5 years post-operation. A trained researcher conducted a clinical assessment which included knee stability, range of motion, alignment and pain. A Knee Score was calculated, with a total score ranging from 0-100 (worst to best).

Complications and survivorship

Information on surgical and medical complications was collected via the self-completed questionnaires and during the clinical assessments, and reported complications were confirmed through review of medical records.

Surgical details

Surgical and prosthetic details were extracted from participants' medical records.

Patient demographics and clinical characteristics

Data on participants' age, gender, socioeconomic status, number of medical co-morbidities *(27)*, and number of painful joints were collected in the pre-operative questionnaire. Data on body mass index (BMI) were extracted from medical records. Pre-operative radiographs were graded for the severity of osteoarthritis using the Kellgren and Lawrence Grading Scheme *(19)*.

Statistical analysis

Continuous baseline characteristics were summarised using the minimum, maximum, mean, standard deviation (SD), median, 25th percentile and 75th percentile. Categorical baseline and surgical characteristics were summarised as number (n) and percentage. Mean WOMAC, KOOS, UCLA, and AKSS knee scores were plotted across the 5 years based on participants with data available at all time points. Alternative plots using all available data at each time point were also created and provided the same patterns of improvement. The proportion responding to surgery was calculated for WOMAC Pain and Function using a 9-point improvement from pre-operative to each post-operative time point and an 11-point improvement for WOMAC Stiffness. For satisfaction, the proportion responding to surgery was calculated as those responding as somewhat or very satisfied with the overall outcome of their operation. Difficulty when kneeling was summarised for each time point using percentages. Best-case survivorship curves were calculated with failure defined as revision such that those who withdrew, died or were lost to follow-up were considered successes.

RESULTS

Participant characteristics

A total of 904 patients listed for a Triathlon knee replacement were approached about the study and 266 patients consented to participate, giving a recruitment rate of 29%. Participant characteristics are presented in Tables 1 and 2. Participants had a mean age of 69 years (range 41-90) and 64% were female. The mean BMI of participants was 31 (range 15-57). The majority of participants (94%) had severe osteoarthritis pre-operatively, defined as a Kellgren and Lawrence score of 3 or 4. The majority of patients had a medial parapatellar approach and a cruciate-retaining prosthesis cemented with Palacos cement (Table 3). The number of participants in the study at each time point are provided in Table 4. At 5 years post-operation 79% of participants completed the questionnaire and joint assessments were conducted for 75%.

Pain, function, stiffness and knee-related quality of life

Mean WOMAC scores over time are displayed in Figure 1 and mean KOOS knee-related quality of life scores in Figure 2. The largest improvements occurred in the first 3 months post-operation. Further smaller improvements were reported between 3 months and 12 months post-operation, and then a plateauing of outcomes was observed up to 5 years post-operation. Table 5 displays the percentage

Table 1. — Participant characteristics – continuous variables

	Min	Max	Mean	SD	Median	25th percentile	75th percentile
Age in years	41	90	69	9.9	70	62	77
BMI	15.0	57.3	31	6.5	30	26.8	35.0
Number of co-morbidities	0	7	1.7	1.4	2	1	3
Number of painful joints	0	9	3.9	2.1	4	2	5

Table 2. — Participant characteristics – categorical variables

		N	%
Gender	Male	97	36.5%
	Female	169	63.5%
Marital status	Married/Cohabiting	171	66.3%
	Widowed	50	19.4%
	Divorced/Single	37	14.3%
Living arrangements	Alone house/flat	61	23.6%
	With others/nursing home	197	76.4%
Ethnicity	White	252	98.1%
	Asian/asian british	3	1.2%
	Black/black british	1	0.4%
	Other	1	0.4%
Educational attainment	Did not complete secondary	45	17.6%
	Completed secondary school	135	52.7%
	Completed post secondary	76	29.7%
Income (past year)	<£5000 p/a	19	8.8%
	£5000-£12499 p/a	79	36.7%
	£12500-£20999 p/a	63	29.3%
	£21000-£29999 p/a	26	12.1%
	>£30000 p/a	28	13.0%
Work situation past 4 weeks	Retired	180	70.0%
	Not retired	77	30.0%
Kellgren and Lawrence score	1	3	1.1%
	2	12	4.6%
	3	148	56.3%
	4	100	38.0%

Table 3. — Surgical details

		N	%
Surgical approach	Medial parapatellar	176	66.2%
	Lateral parapatellar	2	0.8%
	Medial subvastus	87	32.7%
	Missing	1	0.4%
Cruciate ligaments	Cruciate retaining	245	92.1%
	Cruciate sacrificing	21	7.9%

of patients who reported a minimal perceptible clinical improvement (MPCI) of 9 points on the WOMAC Pain and Function scale and 11 points on the WOMAC Stiffness scale at each time point compared to baseline *(8)*. This demonstrated that between 1 year and 5 years post-operation, >90% of patients reported a MPCI in pain. Results were slightly lower for function, with around 83-86% of patients reporting a MPCI in function between 1 year and 5 years post-operation.

Activity levels

Figure 3 displays mean UCLA activity score over time. Unlike the other patient-reported outcomes, little improvement in activity level was evident from pre-operative to any of the post-operative time points.

Satisfaction

The number of patients who were somewhat or very satisfied with the overall outcome of their TKR

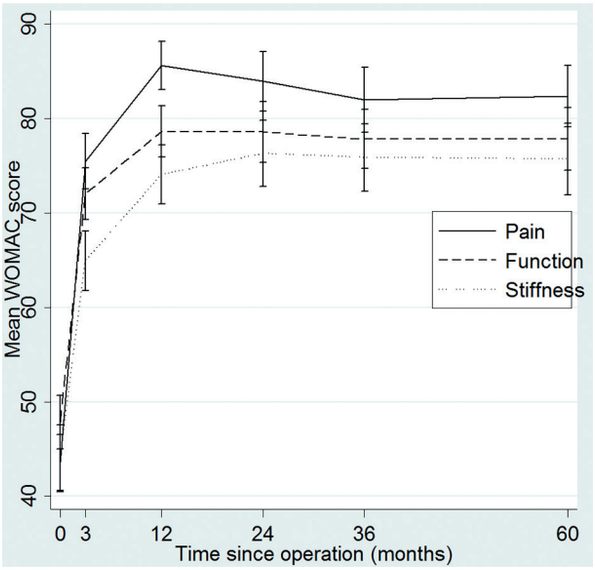

Fig. 1. — WOMAC score over time (mean +/- SD)..

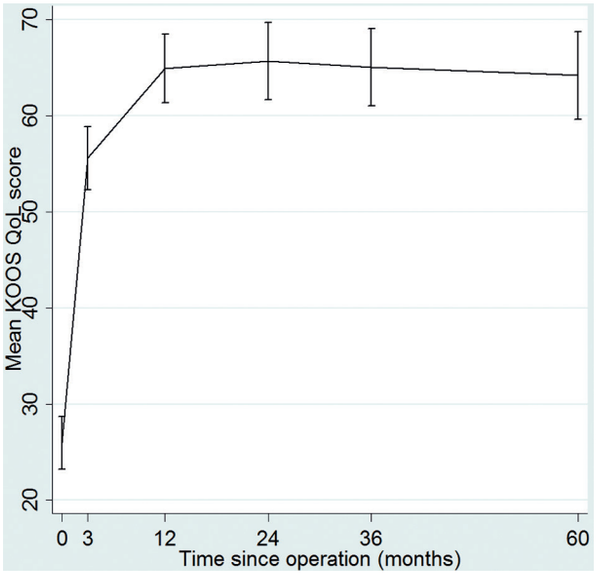

Fig. 2. — KOOS knee-related quality of life score over time (mean +/- SD).

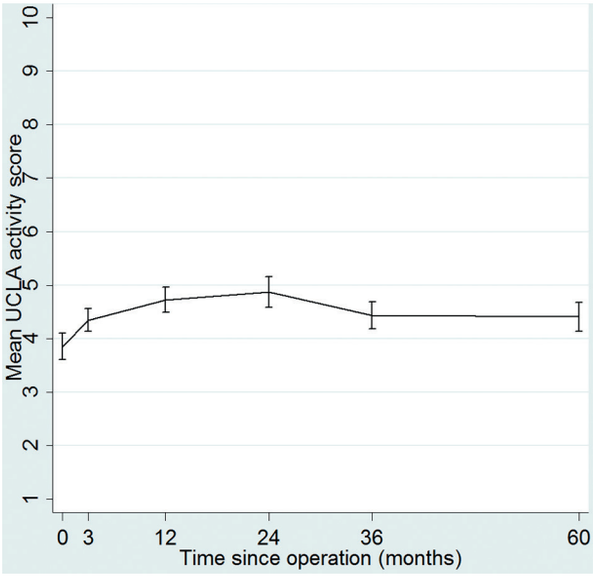

Fig. 3. — UCLA activity score over time (mean +/- SD).

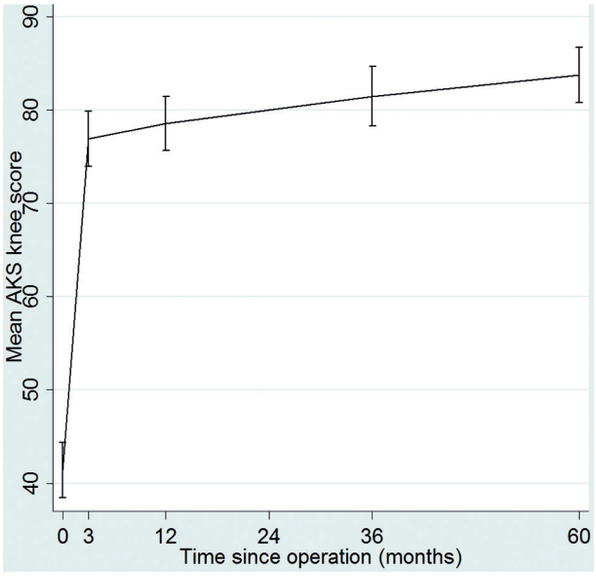

Fig. 4. — AKSS knee score over time (mean +/- SD).

is presented in Table 5. The percentage of patients satisfied with their outcome was highest at 3 months (92%) and 1 year post-operation (91%), and reduced slightly to 86% at 5 years. The percentage of patients who regretted having their operation was low at between 3-5% at each assessment time.

Kneeling

The difficulty that patients experienced when kneeling at each assessment time is displayed in Table 6. Many patients were unable to kneel before surgery, and this only decreased slightly

after surgery from 52% of patients pre-operatively to 46% of patients at 5 years post-operation. The percentage of patients who had not tried to kneel decreased post-operatively, from 26% of patients at 3 months post-operatively to 8% of patients at 5 years.

Table 4. — Number of participants in study at each assessment time

		Number at risk	%
Knee questionnaire	Pre-op	261	98.1%
	3 months post-op	245	92.1%
	1 year post-op	236	88.7%
	2 year post-op	219	82.3%
	3 year post-op	231	86.8%
	5 year post-op	210	78.9%
Joint assessment	Pre-op	254	95.5%
	3 months post-op	228	85.7%
	1 year post-op	215	80.8%
	3 year post-op	218	82.0%
	5 year post-op	199	74.8%
Casewise plots*	WOMAC	144	54.1%
	UCLA KOOS AKSS	153 155 110	57.5% 58.3% 41.4%

* Plots were based on individuals with data available at all time points for each measure (i.e. casewise).

Table 5. — Responders to surgery (%) at each post-operative assessment time

	3 months	1 year	2 year	3 year	5 year
WOMAC Pain*	85.3	94.3	91.5	91.5	91.4
WOMAC Function*	75.3	85.9	84.5	84.5	82.8
WOMAC Stiffness†	66.8	79.3	79.6	79.0	80.6
Satisfaction§	91.7	91.3	88.8	84.9	86.3

* Responders defined as patients reporting a 9 point improvement compared to pre-operative score
† Responders defined as patients reporting a 11 point improvement compared to pre-operative score
§ Responders defined as patients who were somewhat or very satisfied with the overall outcome of their knee replacement

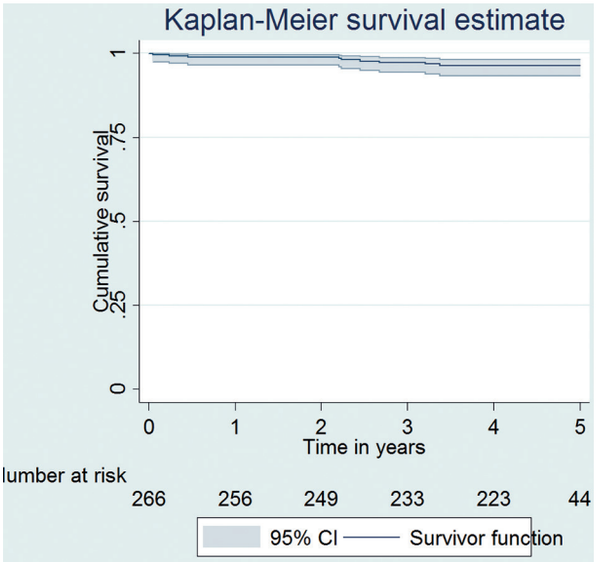

Fig. 5. — Kaplan-Meier survivorship estimate with 95% confidence intervals and number at risk expressed under horizontal axis.

American Knee Society Score

Mean AKSS knee scores over time are displayed in Figure 4. A large improvement was seen from pre-operative to 3 months post-operation, and then a small but gradual improvement continued up to 5 years post-operation.

Survivorship

By 5 years post-operation, 9 (3.4%) patients had revision surgery on their TKR. Reasons for revision included infection (n = 3), malalignment (n = 3), stiffness (n = 1) and aseptic loosening (n = 2). Survivorship with revision of the TKR as the endpoint was 96.6% (95% CI 93.2-98.1%) at 5 years post-operation (Fig. 5).

Table 6. — Difficulty patients experienced when kneeling at each assessment time (%)

	Pre-operative	3 months	1 year	2 year	3 year	5 year
Unable to kneel	51.9	42.4	39.3	43.3	44.9	46.0
With much difficulty	29.9	16.0	27.5	26.0	24.1	21.4
With a little difficulty	14.9	14.4	14.4	17.2	16.2	16.6
Yes, easily	1.7	0.8	4.4	5.1	5.1	8.0
Not tried	1.7	26.3	14.4	8.4	9.7	8.0

Patient Reported Complications

There were 12 deaths not related to the surgery during the follow up period (4.5% ; Table 7). Three thromboembolic events were reported (2 in the first year of follow up, 1 in the third year of follow up ; 1.1%). Two periprosthetic fractures occurred at 1 year and 5 years postoperatively respectively (0.8% ; one treated with supracondylar nailing, one treated with open reduction and internal fixation). One early (0.4% ; underwent debridement and modular exchange) and two late infections were reported (0.8% ; one treated with excision and fusion, the second treated with 2-stage revision). Seven patients reported severe pain (2.6%) with one patient reporting this at both the 1-year and 3-year time points (this patient subsequently underwent the 2-stage revision for infection). Three patients reported sensations of instability (1.1%) with one of these patients reporting this at the 1 and 3 year follow up (two of these patients were revised for diagnoses of malalignment). One patient reported loosening of their implant at the 5-year follow up (0.4%) but did not require revision. Three patients reported swelling of the knee at the 1-year follow up (1.1%) and one patient reported swelling of the knee at the 5-year follow up. Stiffness was reported by 7 patients (2.6%) with one patient reporting this at the 1 and 3-year time points (two of these cases were revised for indications of malalignment and arthrofibrosis respectively). One patient (0.4%) reported an ulcer associated with the incision during the first year of follow up which required superficial debridement.

DISCUSSION

The primary aims of TKR are to provide relief from chronic pain and improve functional ability. However, it is now well documented that a number of patients report continuing pain and functional limitations after surgery *(5, 24)*. Poor outcomes after an elective procedure such as TKR can lead to patient dissatisfaction, poor health-related quality of life and psychological distress *(3, 17)*. Reasons for patients experiencing suboptimal outcomes after TKR can be multi-factorial and complex *(33)*. However, evaluation of different prosthetic designs is important as implant brand can influence outcomes after TKR *(2)*. This cohort study demonstrates that the Triathlon knee replacement results in good patient-reported outcomes, clinical outcomes and survivorship up to 5 years post-operation.

This study had limitations and strengths that should be acknowledged when interpreting the findings. The recruitment rate for the study was low at 29%. This was likely because of the high participation burden of completing multiple questionnaires over a long follow-up period. However, participant demographics are similar to those reported in the National Joint Registry of England, Wales and Northern Ireland *(23)* and

Table 7. — Complications experienced at each assessment time (%)

	1 year		2 year		3 year		5 year	
	n	%	n	%	n	%	n	%
Stiffness	5	1.9%	0	0	3	1.1%	0	0
Periprosthetic fractures	1	0.4%	0	0	0	0	1	0.4%
Infection	0	0	0	0	0	0	2	0.8%
Loosening	0	0	0	0	1	0.4%	1	0.4%
Unexplained pain – severe	2	0.8%	0	0	5	1.9%	1	0.4%
Thromboembolic event	2	0.8%	0	0	1	0.4%	0	0
Swelling	3	1.1%	0	0	0	0	1	0.4%
Instability	2	0.8%	0	0	2	0.8%	0	0
Death not related to TKR	2	0.8%	2	0.8%	1	0.4%	7	2.6%
Other	1	0.4%	0	0	0	0	0	0

The following complications were included in the questionnaires but no subject reported occurrence of these complications: dislocation (tibiofemoral), dislocation (patellofemoral), ligament rupture, metal wear, patella tendon rupture, polyethylene wear, osteolysis, prosthesis fracture.

therefore the sample is likely to be representative of the patient population undergoing TKR. Inclusion of a comprehensive range of assessment methods, including a number of patient-reported outcome measures, clinical knee assessments and survivorship analysis allowed a multi-dimensional approach to outcomes assessment. In addition, the longitudinal study design with regular post-operation follow-up allowed the assessment of change over time. Our rate of data collection was high for all assessment methods, which may be attributable to the implementation of home visits to participants to conduct knee assessments.

A previous study in which patients with a Triathlon knee replacement completed the Oxford Knee Score prior to surgery and then at 6 months, 1 year and 5 years after surgery demonstrated that most improvement occurs in the first 6 months, and then this outcome is maintained up to 5 years[29]. Our study provides further evidence of this outcome trajectory but additionally demonstrates that the initial improvement in outcomes is mainly occurring in the first 3 months post-operation, and that recovery is greater and faster for pain than function. Similar to findings from other studies, these improvement in pain and function are reflected in the satisfaction scores, with a high percentage of patients reporting satisfaction with their outcome up to 5 years *(29)*. The AKSS knee score demonstrated a similar pattern of improvement over time as the patient-reported outcome measures, with the exception that a small but gradual improvement was observed between 1 and 5 years.

The outcomes in which there was little improvement after surgery were activity levels and kneeling. Minimal improvements in activity levels after TKR has been documented in a number of studies *(6, 11, 15)*. Reasons for a lack of improvement in activity levels and participation in sports after surgery are numerous, including pain in the replaced knee, medical advice, fear of damaging the joint, lack of confidence, impact of medical co-morbidities and age *(12, 32)*. Kneeling after TKR is another outcome which is known to be problematic for some patients *(30)*, and patients' expectations of their kneeling ability after TKR surgery are often poorly met *(28)*. Research has suggested that education and advice could improve kneeling after surgery *(18)*, although further research in this area is needed. In conclusion, this study observed good mid-term patient outcomes and survivorship of the Triathlon knee replacement.

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