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Original Article

A retrospective medium- to long-term results of 1500 AGC total knee replacements – An independent centre functional follow up and survivorship

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ABSTRACT

Background: The AGC knee is one of the most widely used knee replacements in the world with good survivorship in national joint registries, including the Swedish within which it remains the gold standard of risk.

Purpose: However, there are few long term survivorship reviews from the centre other than those affiliated with the designer that also offer any insight into functional outcome. In this review, we present the results of one of the largest non-designer, medium- to long term follow-ups of the AGC knee replacement.

Methods: A total of 1538 AGC knees were performed during a 15 year period, of which 902 were followed up by postal or telephone questionnaire using Oxford Knee Scores, Visual Analogue Scores (VASs) of function and pain and survival analysis.

Results: 87.5% of patients reported excellent or good functional reports at final follow up and 90.3% reporting excellent or good pain scores.

There is a mean survivorship of 95.88% at 15 years from the 1538 knees. 85.7% of patients had an Oxford score of between 12 and 40, with 71.2% scoring between 0 and 30. 65.6% of patients responded with a VAS of 0 or 1 at rest (minimum pain = 0) and 53.9% reported a VAS of 0 or 1 while walking.

Interpretation: Our study shows excellent mid to long term results in a large group of patients was achieved using the AGC TKR implanted by a variety of Consultants and trainee surgeons.

This review and data from national registries suggest that in terms of both survivorship and function demonstrate the AGC knee replacement still remains the knee that newer designs must be measured against.

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1. Introduction

The cemented posterior cruciate sparing Anatomical Graduated Component (AGC) knee prosthesis (Biomet, Warsaw; Indiana), in view of its longevity and effectiveness at pain relief is considered the gold standard in knee arthroplasty^{1–4}. The Swedish knee Arthroplasty Register reports a survival of 97.5% at 10 years.¹

The prosthesis has a posterior cruciate retaining design with flat on flat articular geometry. The tibial component is a monoblock using direct compression moulded polyethylene hence eliminating backside wear (the postulate for the implant's longevity).⁵

This AGC design has remained unchanged since 1983 (with both cemented and uncemented versions being available).

The aim of this study was to ascertain the long term survival of the implant and the patient satisfaction in terms of pain and function.

2. Patients and methods

Between 1994 and 2009, in Hastings, United Kingdom, we performed 1538 AGC (Biomet) cruciate retaining total knee replacements (TKRs) in 1291 patients with a mean age of 73.55 years (31–94). A total of 247 (16%) of these patients had bilateral TKRs, of which 63 patients were performed synchronously whilst 184 were staged.

Surgery was performed by a variety of surgeons, including Consultants, training specialist registrars/residents and non-training Staff Grades (19 surgeons in all). A standard technique and incision (midline, medial parapatellar) was used. Most patients had an induction dose and 2 further post-op doses of antibiotic prophylaxis (cefuroxime); until 2007 when the hospital policy changed to just one induction dose and no routine post-operative doses. All patients were encouraged to mobilise fully weight bearing the day after the operation. No routine Continuous Passive Motion equipment (CPM) was used.

The majority of knees (1285) had both components cemented. There were 239 cases where both components were uncemented and 9 hybrid cases. Patellar resurfacing was performed in 612 (39.7%). The majority (60.3%) had patella osteophytes removal without resurfacing.

The patients were reviewed by retrospective follow up postal questionnaire at the time of writing this study. This included Oxford Knee Scores, a patient overall rating and satisfaction score, a Visual Analogue Score for pain (VAS) and a retrospective question as to whether in hindsight they would undertake surgery again. Any patient undergoing bilateral TKRs filled out forms for each side.

All non-responders were sent a repeat questionnaire after a three month period, and any persistent non-responders were followed up by a telephone conversation.

There were 390 patients who had died at the time of data collation. Six of them had received and responded to the questionnaire before their death. The remaining 381 patients were followed up by reviewing of all their medical records and General Practitioners were also contacted to ensure they had

not undergone revision arthroplasty before their death. This data was used in calculating the Kaplan–Meier survival analysis.

The remaining 910 knees were followed up with postal and/or telephone conversations. Of the total cohort, 39 knees (34 patients) were inappropriate for questioning. See [Table 1](#) for reasons. Patients who were less than 1 year post-op follow up were also excluded (229 cases) from the scoring follow up.

3. Results

There was a 95.6% response rate to questionnaires (870/910). The mean time after arthroplasty was 4.87 years.

The mean age of the patients at the time of surgery was 73.55 years (range of 31–94). There were 949 females and 589 males. Indications for surgery are listed below ([Table 2](#)). The vast majority of knee arthroplasties were performed for osteoarthritis.

Time of follow up was as illustrated in the graph below ([Graph 1](#)).

There were 387 patients from 5 to 10 years and 113 between 10 and 15 years.

4. Functional score

4.1. Oxford Knee Scores

Of the 870 responders, 5 of the questionnaires were incompletely filled and therefore not included.

Using the original scoring method (Dawson et al JBJS Vol. 80-B, NO. 1, January) 12 is considered a perfect score with no functional deficit, while 60 is the worst possible score.

[Table 3](#) and [Graph 2](#) illustrates that over 70% of patients consider their knee scores between 0 and 30; signifying an excellent to good functional outcome. Conversely only 10% consider their result to be poor (score of 40–60).

4.2. Visual Analogue Score (VAS)

Visual Analogue Scores were recorded for pain at rest and at walking out of 10 (with 0 considered no pain at all and 10 extreme discomfort). [Table 4](#) demonstrates this distribution.

73% of patients considered themselves to have a VAS of 0–2 at rest and 63% while walking. This indicates they had at very worst “slight discomfort”.

Table 1 – Reasons for exclusion from follow up.

Reasons for loss of contact	Number of knees (patients)
Decreased mental capacity	20 (18)
Unable to contact	8 (7)
Moved abroad	5 (3)
Too medically unwell	4 (4)
Total	37 knees

Table 2 – Indications for surgery.

Indication for surgery	Number of knees
Osteoarthritis	1413
Rheumatoid arthritis	95
Conversion of unicompartmental	17
Psoriatic arthritis	5
Previous trauma	4
Avascular necrosis	1
Previous septic arthritis	1
Previous tibial plateau fracture	1
Chondrocalcinosis	1
Total	1538

Graph 3 is a graphical representation of VAS while at rest (purple bars) and walking (crimson bars).

4.3. Patient rating scores

These were divided into categories of excellent, good, fair/poor, worse than pre-operatively (See Table 5).

A total of 870 patients' responses were recorded.

In terms of functional outcome, 87.7% of patients (763 patients) rated their outcome following surgery to be good to excellent with only 1.3% being worse than pre-operatively.

Similarly, 90.3% of those surveyed described their general satisfaction of the knee as good to excellent with only 3.6% stating it worse than pre-operatively.

5. Response to outcomes of surgery

Patients were asked if they would undergo surgery again. 796 replied as "yes" – (91.3%).

76 replied saying "no" – (8.7%). No further information was asked at this point.

Graph 1 – Time to follow up after arthroplasty.**Table 3 – Distribution of Oxford Knee Scores.**

Oxford knee scores	Number of patients	Percentage of patients (%)
12	46	5.3
13–20	310	35.4
21–30	267	30.5
31–40	163	18.8
41–50	71	8.2
51–60	16	1.8
Total	870	

6. Revision arthroplasty

Out of 1538 knees, 23 were revised at a rate of 1.43%. 4 of these were revised after their responses to the questionnaire. The reasons for revision are listed in table below (Table 6).

Infection remains the leading cause for revision (13 cases); with aseptic loosening representing 6 cases.

7. Complications not requiring revision

This data refers to complications other than revision and correlates to results events directly attributable to the knee operation from all 1538 knees (Table 7).

The majority of the major complications were due to stiffness of unknown origin. 24 returned to theatre for a manipulation under anaesthetic. There were 14 cases of clinically/radiologically confirmed venous thrombo-embolic event (VTE); with 10 Pulmonary Emboli (PE) and 4 deep vein thrombosis (DVT). There were also 18 cases of infection that had either responded to antibiotics or washout and did not result in a revision operation.

8. Summary for AGC survivorship (Kaplan–Meier)

Table 8: summary table for year on year survival (Kaplan–Meier); this illustrates a mean survivorship of 95.88% at 15 years (Graph 4 AGC survivorship at 15–16 years).

Graph 2 – Distribution of Oxford Knee Scores.

Table 4 – Visual Analogue Scores whilst at rest and walking.

Visual analogue score (0–10)	At rest	On mobilisation
0	428 (49%)	356 (41%)
1	113 (13%)	113 (13%)
2	96 (11%)	80 (9%)
3	54 (6%)	44 (5%)
4	46 (5%)	63 (7%)
5	59 (7%)	66 (7%)
6	30 (3%)	30 (3%)
7	25 (3%)	41 (5%)
8	15 (1.5%)	48 (5.5%)
9	1 (>1%)	15 (2%)
10	3 (>1%)	14 (2%)
Total	870	870

NB: a couple of forms were incomplete hence the discrepancy in numbers.

9. Discussion

In 1995 the designer surgeon reported 10-year survivorship of the AGC knee of 98%. Subsequently he has reported 15 and 20 year survivorship at 98.6%⁶ & 97.8%⁷ respectively. Other authors have also reported excellent long term survivorship of this prosthesis. Because of its excellent survivorship reported in the Swedish Knee Arthroplasty Register,¹ the AGC has been regarded by many as the gold standard by which other prostheses should be benchmarked.

The successful long term survivorship of the AGC has been attributed to its key design features.⁸ The flat on flat geometry of the articulation combined with the monoblock tibial design and the direct compression moulded polyethylene manufacture has been responsible for extremely low rates of polyethylene wear on the articular surface and prevented backside polyethylene wear altogether. Consequently osteolysis and aseptic loosening has not been seen to anything like the same degree with the AGC as in other leading modular designs.^{8–10}

One criticism of the AGC has been that the Universal (non-sided) design of the femoral component may lead to poor patellar tracking. This is unproven, but for surgeons who are

Graph 3 – Graphical representation of VAS.**Table 5 – Distribution of patients' functional and satisfaction scores.**

	Explanation of score	Numbers of patients
Overall rating (pain, activity level, movement)		
Excellent	No pain, normal activity	258 (29.6%)
Good	Occasional discomfort	503 (57.9%)
Fair to poor	Pain most of the time, sig. loss of flexion	98 (11.2%)
Worse	Pain increased (cf. pre-op)	10 (1.3%)
Satisfaction		
Excellent	Minimal pain	423 (48.6%)
Good	Better than before surgery	363 (41.7%)
Fair/poor	Same as before surgery	52 (6.2%)
Poor	Worse than before the surgery	31 (3.6%)

NB: a couple of forms were incomplete hence the discrepancy in numbers.

Table 6 – Reasons and incidents of revision arthroplasty following AGC knee.

Indication	Numbers
Infection	13
Aseptic loosening of	
- Tibial component	4
- Both components	1
- Patella button	1
Instability	2
Fracture following trauma	2
Unexplained knee pain	1
Total	23

concerned, left and right sided femoral components have been available since 1987.

It has also been suggested that newer designs of knee replacement may achieve better functional results and a

Table 7 – Reasons and incidents of complications.

Complication	Number
Manipulation under anaesthesia	26
PE	10
DVT	4
Wound infection	
- Requiring washout	8
- IV antibiotics only	7
Chronic infection	3
Haemarthrosis – requiring washout	7
Intraoperative fracture	6
Cardiac events (MI, CVA, LVF*)	3
GI Bleeding	2
Patella mal-tracking requiring re-operation	3
Periprosthetic fracture requiring surgery	2
Ruptured patellar tendon	1
Loose tibial component	1
Drain remnant left in site (req. removal)	1
Death (2° PE or MI)	3
Total	168

MI = Myocardial Infarction, CVA = Cerebrovascular Accident, LVF = Left Ventricular Failure, GI = Gastrointestinal, Death = specifically attributable to the arthroplasty.

Table 8 – Summary table for year on year survival (Kaplan–Meier).

Year since operation	Number at start	Failure	With-drawn	Number at risk	Survival rate	95% CI
0 to 1	1754	5	227	1640.5	99.76%	
1 to 2	1522	5	200	1422	99.42%	
2 to 3	1317	3	198	1218	99.18%	
3 to 4	1116	0	125	1053.5	99.18%	
4 to 5	991	1	146	918	99.10%	98.61–99.59%
5 to 6	844	2	107	790.5	98.88%	
6 to 7	735	2	101	684.5	98.62%	
7 to 8	632	0	131	566.5	98.62%	
8 to 9	501	3	70	466	98.06%	
9 to 10	428	1	87	384.5	97.85%	96.83–98.86%
10 to 11	340	1	105	287.5	97.29%	
11 to 12	234	0	104	182	97.29%	
12 to 13	130	0	61	99.5	97.29%	
13 to 14	69	1	48	45	95.88%	
14 to 15	20	0	11	14.5	95.88%	92.86–98.90%
15 to 16	9	0	7	5.5	95.88%	

greater range of motion by way of design changes to all three components and by introducing a greater range of sizes. Again this is unproven and many newer designs have been shown to perform less well than the AGC.

Our study of over 1500 cases has confirmed the excellent long term survivorship reported by the designer surgeon,^{5–8,11} other independent authors^{12–15} and the Knee Arthroplasty Joint Registries.^{1,2,4,16} We have also shown that excellent long term results can be achieved in a District Community Hospital setting when the surgery has often been carried out by trainees, non-training grades and Consultants whose main expertise is not in knee surgery.

We have also shown that good functional results are achieved using the AGC. With a 95.88% survivorship at 15 years, 70% of patients have good Oxford Knee Scores, and VAS scores are between 0 and 2 at rest and walking of 73% and 63% respectively represent excellent results.

Despite being in service for almost thirty years, we believe that the AGC should continue to be regarded as the gold

standard that newer designs should be benchmarked against in terms of function, pain relief and long term survivorship.

Contribution of authors

Atrey A – Main author. Writing of the paper.

Edmondson M – Secondary author. Helped in writing the paper.

East D – Research coordinator.

Sullivan K – Research physiotherapist – ran the follow up clinic.

Ellens N – “A research physiotherapist and helped in assessing the patients in clinic.”

Butler-Manuel A – Head of research group. Edited the paper and instigated the project.

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“The Authors did not receive sponsorship in respect of this paper. However the senior author, Mr A Butler-Manuel, lectures and takes part in educational meetings in the field of Knee Arthroplasty on behalf of Biomet Inc. He does receive payment specifically for presenting at these meetings.”

Conflicts of interest

All authors have none to declare.

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Graph 4 – The Kaplan–Meier survivorship of AGC knees to over 15 years.

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