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ORIGINAL STUDY

The Denham prosthesis in revision knee surgery A 10 year follow-up

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We studied the Denham knee prosthesis (Biomet, Warsaw, IN) in revision of total knee arthroplasty (TKA) in situations of extreme bone loss or ligamentous disruption including revision from previous hinged implants. We reviewed 34 patients (38 knees) at an average of 7. 5 years after surgery (range 4-12 years). No patient was lost to follow-up although 15 unrelated deaths occurred during the study. There were six failures, of which five were due to infections in patients who received a revision for infection. A further two patients experienced a poor result. The remaining 30 patients had an excellent or good result. In our setting, the Denham TKA effectively addressed problems of loss of bone stock and ligamentous disruption with simple instrumentation and a remarkably small number of implants.

INTRODUCTION

The Denham total knee prosthesis (Biomet, Warsaw, IN) (TKA) is a semi-constrained, uni-centric and fully congruous prosthesis in which the posterior cruciate ligament is excised and the patella is not resurfaced. It was first implanted in 1976 in the light of the fact that existing knee replacements at the time were unable to provide consistent and reliable results in terms of survivorship or function (*10*). Originally designed to meet the limited needs of the elderly arthritic patient, long-term results in primary knee arthroplasty compare well with other series, allowing pain relief with correction of deformity and acceptable mobility in this elderly age group (*6, 8, 10*).

The prosthesis was used in a number of centers in the U.K. in the 1970s and 1980s but its use now in primary TKA is confined to a few centers, most notably in the region of its origin. Whilst the authors accept in its present form the prosthesis is unlikely to achieve new converts in primary TKA ; its valuable role in revision knee surgery has not been previously acknowledged. There have been no previously published clinical results of the Denham TKA in revision knee surgery and we think its results are worth presented to a wider audience.

We believe the Denham TKA has provided a role in revision knee surgery by offering a simple, easily inserted prosthesis with high patient satisfaction and good long-term survival. Its use is best suited to the difficult knee with substantial bone loss, with significant instability due to soft tissue disruption

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or with gross deformity. It has provided an alternative to the more conventional total condylar and constrained hinge designs. Therefore we report our own experience with the Denham TKA in revision knee surgery.

PATIENTS AND METHODS

Details of all patients who had revision knee surgery with the Denham TKA were identified using theatre records. Case notes were then pulled from file and the relevant data obtained. This data was cross-referenced against data stored on index cards designed by Denham and used by the senior author.

These index cards are updated after every outpatient visit and include information on demographics, a pre-operative joint assessment, perioperative complications and postoperative status in numerical form.

We recorded patient details (age, sex) along with diagnosis, type of knee arthroplasty and reason for revision. Pre-operative assessment included duration of symptoms (years or months), assessment of pain, joint movement, deformity and function. Peri-operative and post-operative complications were recorded, along with their effect on treatment.

Follow-up consisted of out patient assessment at six months, one year, two years and at two-yearly intervals thereafter. The unique rural environment of the Highlands with strong local links to the hospital has meant that follow-up has been excellent : excluding deaths, no patient has been lost to follow up. At each follow up clinic, patients were asked their opinion about pain, progress, movement and satisfaction from surgery. The knee was then assessed clinically recording position, swelling, movement and joint function. Radiographs were then taken. Any radiolucency near components, or fracture or displacement of the cement was noted. The present state of the arthroplasty was then assessed in overall terms by the examining surgeon.

An indicator of outcome was based on a points scoring system devised initially by Denham which gave 0-5 for each of 5 factors : Patients opinion, surgeons opinion, pain, movement and function (4). Using these 5 criteria the outcome was then classified as either excellent, good, fair, poor, very bad or permanent failure.

Patients regarded pain as by far the most important feature of the result and in clinical review it became clear that pain level and the patient's satisfaction were closely linked together forming the best simple criterion for success.

A permanent failure was a patient with severe constant pain, minimal joint movement and poor joint function. Further revision surgery or an arthrodesis was regarded as a permanent failure.

Prosthesis

The prosthesis is a semi-constrained, uni-centric and fully congruous design in which the posterior cruciate ligament is excised and the patella is not resurfaced (figs1 and 2). The articulating surfaces are matching parts of a regular cylinder with an area adequate to eliminate excess wear and a radius small enough to provide anteroposterior stability. The tibial prosthesis is as wide as the upper tibia in the coronal plane to give a broad bearing surface. This feature, together with the built-in accuracy of valgus alignment, means that the forces of weight bearing pass through the central third of the prosthesis. This greatly reduces the lateral pressures, which have been shown, experimentally and clinically, to lead to tilt, over-pressure and failure (*1, 7*).

Operative Technique

The senior author (DFF) performed all procedures closely following the original operative technique described by Denham. At induction of anaesthesia 1.5 g cefuroxine and. 5 g metronidazole are given intravenously and a high thigh tourniquet is applied with exsanguination. Antibiotic administration was deferred when there was any suspicion of infection to allow accurate cultures to be obtained.

A long straight anterior skin incision was used unless previous scars dictate a different approach, and the joint exposed through a medial parapatellar approach. Upon entering the joint, swabs of synovial fluid are taken for immediate Gram stain analysis, and for aerobic and anaerobic culture. Specimens of the retroprosthetic membrane are also sent for culture. Solid knee arthroplasty components are then removed and the joint is debrided removing all cement and as much fibrous tissue as possible.

The essential feature of the operation is its simplicity. A long femoral intramedullary rod carrying a template is introduced into the femoral cavity at the lower end of the femur. This template is at 7 degrees valgus to the transverse plane of the femoral shaft and its rotation is set by reference to the plane of the femoral condyles. The correct position of rotation upon the tibial plateau is obtained by using a tibial trial prosthesis, positioned with respect to the trial femoral component.

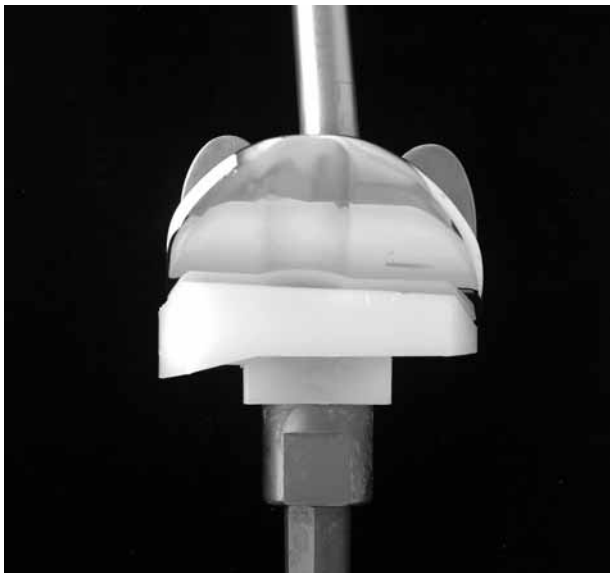

Fig. 1. — Denham knee prosthesis (AP).

Fig. 2. — Lateral view of the prosthesis.

The tibial articulating surface is cut without a jig. A temporary long intramedullary rod transfixes the tibial component. This rod, which is removed when the cement is setting, ensures the tibial alignment is at 90 degrees to the shaft of the tibia. A special wedged prosthesis is available to compensate for excessive bone loss on either the medial or lateral side. This avoids filling the defect with a triangle of cement, which could displace, leaving the peripheral part of the prosthesis unsupported.

Metal tibial revision stems are available to screw into the metal backing of the tibial component to improve fixation if severe tibial condyle damage is present. The posterior aspect of the tibial component is on occasions trimmed off to improve flexion, although, if greater stability was required, this procedure is not performed.

Cementing is carried out separately for each component. When the tibial component has been securely cemented final fittings are made of the femoral prosthesis, relying on its thick intramedullary stem to align the joint surface in 7 degrees valgus.

Finally, the definitive femoral prosthesis is pressed into a bed of hardening methylmethacrylate cement by extending the knee fully against the tension of the posterior capsule and ligaments, thus ensuring that there will be biological limitation to prevent overextension. While this is done, the valgus alignment of the femur and tibia is ensured by the stemmed prosthesis.

Suction drains were used in the early part of the series but were later abandoned (*3*). Postoperatively, quadriceps exercises and gentle knee bending are usually begun the first post-operative day. The patient is allowed to mobilise as soon as possible post operatively. Splintage was only used if there was gross ligamentous laxity persisting at the end of the procedure, for example after revision of a previous hinge prosthesis.

RESULTS

Between August 1987 and September 1998 38 TKAs (34 patients) were revised by the senior author using the Denham TKA.

There were 24 women and 14 men with a mean age of 67.5 years (range 45-86 years) with 21 knees affected by rheumatoid arthritis and 17 by osteoarthritis. Both knees were replaced in 4 patients, and, of the remainder, 14 left and 16 right knees were revised.

The mean duration of follow-up was 7.5 years (range 4-12 years). No patient was lost to follow-up and 15 deaths occurred in the series.

Indications for revision were varied, the most common indication being aseptic loosening (table I). Failed prostheses included Guepar (*11*), Geomedic (*11*), Oxford (*2*), Kinematic (*10*), and Denham (*4*).

Table I. — Indications for revision

Indications for revision	No.	Percentage
Aseptic loosening	29	76.1
Infection	5	13.1
Aseptic loosening plus medial tibial plateau fracture	2	5.3
Supracondylar fracture above prosthesis	1	2.6
Aseptic loosening plus broken prosthesis	1	2.6

Pre-operative knee assessment graded 23 patients as having either severe intermittent or severe constant pain and 21 patients as having a poor or very poor joint function. The most common difficulty encountered at operation was dealing with severe bony erosions and bone loss in several patients.

Complications after surgery

Thirty-one patients had an unremarkable post-operative recovery while the remaining seven patients had various minor complications the most serious being a stiff knee, which required a manipulation under anaesthesia and a haemarthrosis, caused by the patient being started on Warfarin elsewhere. There were no deaths in the series before six months, and no late deaths directly related to surgery.

Permanent failures

There were six permanent failures. Five of these were due to infection with two patients requiring arthrodesis (2 years, 4 years) and two patients further revision surgery (2 years, 4 years). One patient developed a painful chronic low-grade infection at 4 years but is unfit for major revision surgery. In all five patients the revision knee surgery was initially performed for infection.

One patient with severe and constant pain at 6 months was classified a permanent failure, although it was not possible to fully separate knee pain from pain due to severe rheumatoid arthritis in other joints. This patient was the first patient in the series, and may represent a failure whilst in the learning curve of the procedure.

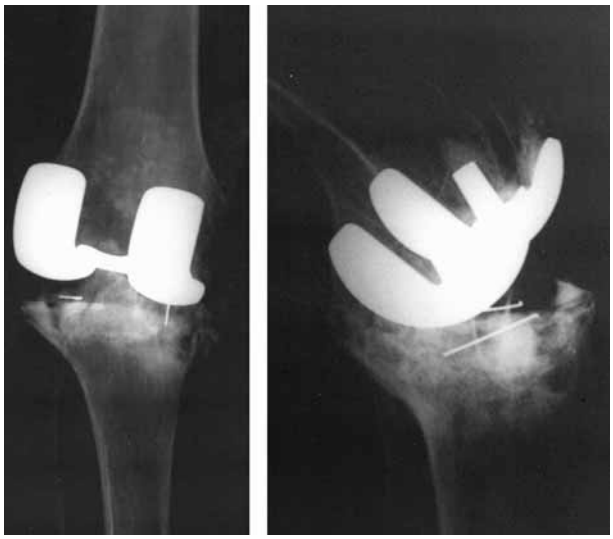

Fig. 3. — Preoperative radiographs : 59-year-old rheumatoid female with aseptic loosening of a Geomedic prosthesis.

Clinical Findings

Two patients were classified as having a poor result from surgery. In one patient, the patellar tendon had been avulsed at surgery and this probably contributed to his poor result. A manipulation under anaesthesia was required after surgery, and a patellectomy performed at 4 years for chronic patella pain without benefit. The other patient developed chronic knee pain at 4 years without any obvious cause, the presentation being of a reflex sympathetic dystrophy of the lower limb.

The remaining 30 patients had either an excellent or good result from surgery with minimal or no pain and acceptable joint movement and function (table II) (figs 3 and 4).

Survivorship Analysis

A life table analysis was then calculated according to the methods of Dobbs (*5*) and of Taw and Waugh (*11*) (table III and fig 5). Confidence intervals were calculated according to the Greenwood equation. At the 5-year interval, 25 patients were at risk and at 10 years, 10.5 patients. This gave survivorship figures of 82.65% at 5 years and 82.65% at 10 years.

Table II. — Pre-operative and post-operative patient assessment

	Pre-operative Assessment				Post-operative Assessment							
Cases	Pain	Joint Movement	Joint Deformity	Joint Function	Operation	Overall clinical result	Patients opinion	Doctors' opinion	Pain	Joint movement	Joint function	F/U (Years)
1	Severe Remittent	Half	Minimal	Very Poor	V.Difficult, under 2 hours	Excellent	Excellent	Excellent	None	3/4 Normal	Normal	12
2	Slight	Half	Severe	Fair	Difficult under 90 minutes	Excellent	Excellent	Excellent	None	3/4 Normal	Normal	12
3	Moderate Remittent	Half	Moderate	Fair	Difficult under 90 minutes	Excellent	Excellent	Excellent	None	Half	Good	12
4	Severe Remittent	Half	Nil	Poor	Over 2 hours	Excellent	Excellent	Excellent	None	3/4 Normal	Good	11
5	Moderate Remittent	Half	Moderate	Fair	Difficult under 90 minutes	Excellent	Excellent	Excellent	None	3/4 Normal	Normal	9
6	Moderate Remittent	Half	Moderate	Fair	Difficult under 90 minutes	Excellent	Excellent	Excellent	None	3/4 Normal	Normal	9
7	Moderate Remittent	Minimal	Minimal	Fair	Difficult under 90 minutes	Good	Good	Excellent	None	Quarter	Good	7
8	Severe Constant	Minimal	Severe	Very Poor	Over 2 hours	Excellent	Excellent	Excellent	None	3/4 Normal	Good	8
9	Severe Remittent	3/4 Normal	Moderate	Poor	Over 2 hours	Excellent	Excellent	Excellent	None	Normal	Good	6
10	Severe Constant	3/4 Normal	Moderate	Poor	Over 2 hours	Excellent	Excellent	Excellent	None	Normal	Good	5
11	Moderate Constant	3/4 Normal	Moderate	Poor	Over 2 hours	Excellent	Excellent	Excellent	None	Normal	Good	9
12	Severe Remittent	Quarter	Severe	Very Poor	V.Difficult, under 2 hours	Excellent	Excellent	Excellent	None	3/4 Normal	Good	10
13	Moderate Remittent	3/4 Normal	Nil	Fair	Difficult under 90 minutes	Good	Good	Good	None	Half	Good	11
14	Severe Remittent	3/4 Normal	Minimal	Fair	Difficult under 90 minutes	Excellent	Excellent	Excellent	None	Normal	Good	8
15	Severe Remittent	Half	Moderate	Poor	Routine	Excellent	Excellent	Excellent	None	Normal	Good	7
16	Severe Remittent	Half	Severe	Fair	Over 2 hours	Excellent	Excellent	Excellent	None	Normal	Good	7
17	Severe Constant	3/4 Normal	Nil	Poor	Over 2 hours	Excellent	Excellent	Excellent	None	Normal	Good	7
18	Moderate Remittent	3/4 Normal	Severe	Fair	Under 2 hours	Excellent	Excellent	Excellent	None	Normal	Good	4
19	Moderate Remittent	3/4 Normal	Moderate	Poor	Over 2 hours	Excellent	Good	Good	None	Normal	Good	5
20	Moderate Remittent	Half	Moderate	Poor	V.Difficult, under 2 hours	Excellent	Good	Excellent	None	3/4 Normal	Good	7
21	Severe Constant	Half	Nil	Very Poor	Over 2 hours	Good	Good	Good	None	Half	Good	5
22	Severe Remittent	Half	Nil	Poor	Under 2 hours	Good	Good	Good	None	Half	Good	4
23	Severe Remittent	Half	Severe	Poor	Under 2 hours	Excellent	Good	Good	None	Normal	Good	4
24	Severe Remittent	Half	Nil	Fair	Under 2 hours	Poor	Poor	Poor	Moderate and constant	3/4 Normal	Poor	10
25	Severe Remittent	Half	Minimal	Fair	Difficult under 90 minutes	Poor	Poor	Fair	Moderate and intermittent	Half	Fair	11
26	Moderate Remittent	3/4 Normal	Moderate	Poor	V.Difficult, under 2 hours	Permanent Failure	Permanent Failure	Bad	Severe and constant	Normal	Very poor	4
27	Severe Constant	Minimal	Minimal	Very Poor	V.Difficult, under 2 hours	Permanent Failure	Permanent Failure	Bad	Severe and constant	Minimal	Very poor	.5
28	Severe Remittent	3/4 Normal	Moderate	Poor	Over 2 hours	Excellent	Excellent	Excellent	None	Normal	Good	2
29	Moderate Constant	Half	Minimal	Poor	Difficult under 90 minutes	Excellent	Excellent	Excellent	None	Normal	Good	1
30	Severe Remittent	Half	Nil	Poor	Routine	Good	Good	Good	None	3/4 Normal	Good	2
31	Moderate Remittent	Half	Minimal	Fair	Difficult under 90 minutes	Excellent	Good	Excellent	Slight	3/4 Normal	Good	3
32	Severe Constant	Half	Severe	Very Poor	Over 2 hours	Good	Good	Good	None	3/4 Normal	Good	3
33	Severe Constant	3/4 Normal	Moderate	Poor	Over 2 hours	Good	Good	Good	None	3/4 Normal	Good	4
34	Severe Constant	Half	Moderate	Fair	V.Difficult, under 2 hours	Good	Good	Excellent	None	Half	Good	.5
35	None	Half	Minimal	Poor	V.Difficult, under 2 hours	Permanent Failure	Permanent Failure	Very Bad	Severe and constant	Half	Very poor	5
36	Moderate Remittent	Half	Nil	Good	Difficult under 90 minutes	Permanent Failure	Permanent Failure	Poor	Severe and remittent	Half	Poor	2
37	Severe Remittent	Half	Nil	Fair	V.Difficult, under 2 hours	Permanent Failure	Permanent Failure	Poor	Severe and remittent	Half	Poor	1
38	Severe Remittent	Half	Minimal	Fair	Routine	Permanent Failure	Permanent Failure	Very bad	Severe and remittent	Quarter	Fair	4

Table III. — Survival life table analysis of revision Denham TKA

Interval since operation (years)	Number at start	Failure	Withdrawn	Died	Number at risk	Probability of removal	Probability of survival	Survival rate	95% Confidence Interval (Upper Limit)	95% Confidence Interval (Lower Limit)
1	38	1	0	1	37.5	0.0267	0.973	97.368	100	94.668
2	36	2	0	1	35.5	0.06	0.94	91.959	100	91.959
3	33	0	0	2	32	0	1	91.959	100	91.959
4	31	2	0	2	30	0.67	0.933	85.828	100	85.828
5	27	1	3	1	25	0.04	0.96	82.65	96.32	74.26
6	22	0	1	2	20.5	0	1	82.65	96.32	69.95
7	19	0	0	1	18.5	0	1	82.65	95.36	69.95
8	18	0	4	1	15.5	0	1	82.65	95.36	69.95
9	13	0	1	1	12	0	1	82.65	95.36	69.95
10	11	0	1	0	10.5	0	1	82.65	95.36	69.95
11	10	0	2	2	8	0	1	82.65	95.36	69.95
12	6	0	2	1	4.5	0	1	82.65	95.36	69.95

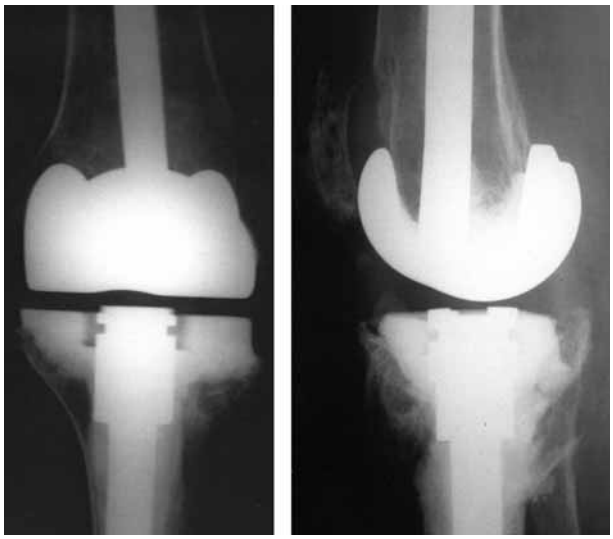

Fig. 4. — Postoperative radiographs following revision to Denham prosthesis.

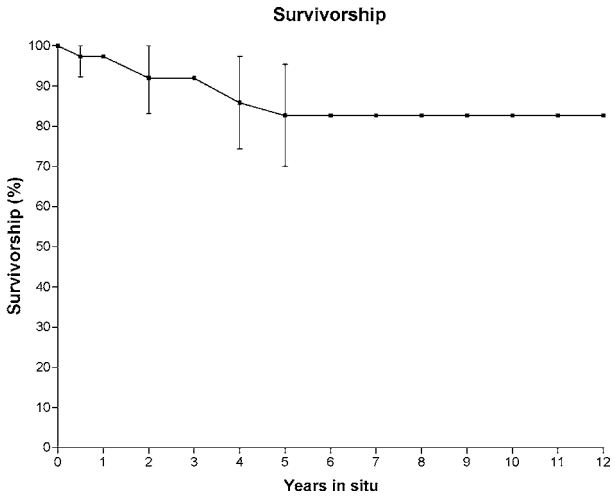

Fig. 5. — Survival curve of Denham TKA in revision knee surgery.

DISCUSSION

The senior author first used the Denham TKA in revision knee surgery in 1987. The prosthesis was originally chosen in order to address the severe bone destruction seen with the loose Guepar prosthesis.

Revision of a hinged (Guepar) prosthesis needs a highly stable implant for a successful outcome. The severe loss of bone stock associated with condylar implants requires stems, a stable implant and defect fillers for successful revision. Mal-alignment of the knee also needs good correction at revision surgery. In addition, the simple nature of the prosthesis without numerous modular add-ons limits the possibility of fretting and crevice corrosion, and increased wear debris from non-bearing surface sources (*2*).

Loss of rotation in our series is not a problem. Rotation is corrected by a medial-lateral translation occurring during flexion/extension but this only occurs readily if the posterior cruciate ligament (PCL) and popliteal ligament are divided. Flexion greater than that predicted by Denham occurred in severely destroyed knees with an absent PCL. The PCL impinged on the posterior edge of the tibia when intact. The constraint within the design precludes the need for the PCL, and therefore we now routinely divide the PCL to improve movement.

The authors acknowledge the foresight and hard work of Mr.Robin Denham in setting up his card index system to follow up a series of 440 knee replacements between 1976 and 1989. However one draw back of this study is the limitation of his scoring system in the light of newer more specific ones available for revision knee surgery (*9*). We also accept that the relatively small numbers of patients included in this series are a further limitation.

CONCLUSIONS

This study has shown the Denham TKA has provided an alternative solution in difficult knee revisions where substantial bone loss, significant instability or gross deformity exists. It is a relatively easily inserted prosthesis with high patient satisfaction and good long-term results.

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