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1 **Long term results of a total knee prosthesis utilising**
2
3 **an all polyethylene tibial component**

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10
11 **Abstract :**

12 **Introduction:** The aim of this study was to assess the long term performance of a of a cemented total
13 knee replacement utilising an All Polyethylene Tibial (APT) component and in addition to perform an
14 engineering analysis of any failures to help refine surgical technique.

15 **Materials & Methods:** A total of 26 patients had a total knee replacement performed using a cemented
16 cruciate retaining Depuy Press Fit Condylar (PFC) APT component and a cruciate retaining femoral
17 component. At final review all patients were assessed using The Knee Society Score together with
18 radiographs. An engineering analysis simulated loading conditions of the implants that failed and these
19 were compared with the performance of a modular Metal Backed Tibial (MBT) component.

20 **Results:** A total of 20 patients were reviewed at mean time of 116 months following surgery. Knee
21 Society Knee Scores and Function Scores in this cohort were 84/100 and 58/100 respectively. Two
22 patients required revision for tibial component failure. Pre-operatively both had valgus deformities and
23 in each case the tibial tray had been lateralised leaving a gap on the medial side where the APT
24 component had no rigid support. The engineering analysis demonstrated that the volume of highly
25 strained cancellous bone was greater in the APT design compared to the MBT design when a model
26 with a 3mm medial gap was loaded. The stiffer MBT base plate acted more rigidly and shielded the
27 stress applied to the proximal tibial cancellous bone.

28 **Conclusion:** The APT component demonstrated excellent clinical and radiographic performance at
29 long term follow up. An engineering analysis of the failures in our case series suggests that careful
30 placement of the implant on the prepared tibial surface with appropriate cortical support may be
31 important in patients with poor bone quality and this has added to our understanding of the surgical
32 technique required when using this implant.

33 **Keywords :** Total; knee; replacement; all; polyethylene; tibia

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35

36 **Introduction :**

37 There has been recent renewed interest in knee replacements employing the use of an APT component.

38 [1-5] The decreased cost of such implants over MBT modular components may help to reduce overall

39 costs. [5,9,10] Modern tibial components employing such a design have been shown to have excellent

40 clinical results and long term survivorship. [4,6,7,8] APT knee replacements avoid locking mechanism

41 issues and backside wear associated with MBT components and the possible osteolysis that this may

42 cause. [11,12] The APT component also allows increased polyethylene thickness with the same amount

43 of bone resection as seen with a similar sized MBT component. Gioe & Maheshwari have summarised

44 the advantages and disadvantages of APT and MBT components.[2] Our study reviews the

45 approximate ten year results and overall survivorship of a knee replacement employing an APT

46 component. An engineering analysis of the two failures within the cohort has increased our

47 understanding of the surgical technique required for this implant and may aid in patient selection.

48 **Material & Methods :**

49 Local ethical committee and written informed consent was obtained from all patients. The indication

50 for surgery was symptomatic osteoarthritis of the knee in all cases. All patients had their surgery

51 performed as per the surgical technique for the implant. In all cases the tibial component implanted was

52 a cemented PFC Sigma cruciate retaining APT component (Depuy, Johnson & Johnson, Leeds, UK)

53 (Fig 1) and a cemented PFC Sigma cruciate retaining femoral component. The Knee Society Score [13]

54 was used to assess all patients at the time of final follow up, pre-operative Knee Society Scores were

55 not available. Antero-posterior and lateral radiographs were obtained at the time of final follow up and

56 compared with previous radiographs for the presence and size of radiolucent lines at the bone-

57 prosthesis interface of the tibial component using the Knee Society Total Knee Arthroplasty

58 radiographic evaluation system. [14]

59 An engineering analysis using a three-dimensional finite element model of an idealised proximal tibia

60 with and without a metal backed tibial tray was generated using the Ansys ver. 6.0 modelling software
61 (ANSYS Inc., PA, USA). The shape of the tibial tray was idealised to be an elliptical shape perfectly
62 bonded to a 2mm Poly Methyl Meth Acrylate layer on the superior surface of the cancellous and
63 cortical bone (1mm cortex). The effect of tibial tray coverage (lateralization of the tibial tray) was
64 investigated by introducing a medial gap of 3mm on the superior cut surface of the tibia between the
65 medial edge of the tibial tray and the cortical bone. An inferior load of 3200 N (4 x BW) was applied
66 centrally to the superior surface of the medial tibial condyle simulating lateral lift-off during walking
67 (Fig 2). The cancellous bone was modelled as an elastic/plastic material to allow collapse if the load
68 exceeded the yield stress, while the remaining materials were modelled elastically. The mechanical
69 properties of the cancellous bone were based on those of an 80 year old patient without disease (yield
70 stress 4.5 MPa). [15]

71 **Results :**

72 Between May 2000 and October 2002, 26 patients, 18 females and 8 males, had total knee
73 replacements performed with APT components. The mean age of patients was 69.7 years at the time of
74 surgery (range 58 - 81). One patient had died at the time of latest follow up, 3 patients declined follow
75 up but were having no problems with their knees and two were revised leaving a total of 20 patients
76 available for long term review (77 % of the original cohort). Mean duration of follow up was 116
77 months (sd 7.95). At follow up, patients' mean Knee Society Knee Score and Function scores were 84
78 (sd 7) and 58 (sd 17.8). No radiolucencies were identified at the bone-prosthesis interface (of either the
79 tibial and femoral components) of the 20 remaining patients who had not required revision surgery at
80 10 year follow up. One patient sustained a late periprosthetic femoral fracture following a fall 55
81 months after their index procedure which successfully united following plate fixation. Survivorship of
82 the implants in this study available for long term follow up was 91 % (20/22). Pre-operatively the two
83 patients requiring revision had a valgus deformity (Fig 3a) and in both the tibial tray was lateralised
84 (Fig 3b), leaving a gap on the medial side of the APT component which had no cortical support. Both
85 patients suffered from medial collapse with subsidence of the tibial tray within 2 years of their surgery
86 (Fig 3c).

87 The engineering theoretical analysis demonstrated that the volume of highly strained cancellous bone,
88 shown by the size of the coloured area in Figures 4a & 4b, was greater in the APT design (Fig 4a)
89 (75% load transfer) compared to the MBT design (48%) (Fig 4b) when a 3mm medial gap was present.
90
91 The stiffer metal backed tibial base plate acted more rigidly and shielded the stress applied to the
92 proximal tibial cancellous bone compared to the all polyethylene tibial component. The engineering
93 explanation of the failures explained the macroscopic observations that the two failed APT implants
94 were bent in the centre with the medial side sloping inferiorly.
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99 **Discussion :**

100 Previous studies of early APT components showed high failure rates with aseptic loosening that was
101 attributed to poor surgical technique or errors in design. [16,17] Design features of significance
102 included polyethylene type and implant conformity which may be a particularly important factor in the
103 design of APT components [18] . Farris & Ritter [18] compared the performance of a compression
104 moulded APT component with a minimum thickness of 10mm, with that of the AGC MBT (Biomet,
105 Warsaw, Indiana, USA) total knee replacement. The AGC knee was designed with the same geometry
106 (flat on flat in the coronal plane) as the APT and had a 15 year survivorship of 98.86 %. [19] Farris &
107 Ritter [18] found that the APT had a disappointing 68.11% 10 year survival. They postulated that this
108 was due to low conformity of the implant which led to peripheral edge loading on the upper tibial
109 surface which was not seen with the MBT. Our engineering analysis demonstrated that the load transfer
110 within the cancellous bone of the proximal tibia was greater in the APT design compared to the MBT
111 design. This is purely related to the stiffness of the metal backed tray and not to the specific
112 manufacturers' design as design details were not modelled in our study.
113 Tibial coverage is challenging in knees as the posterior medial tibial bone is not generally well covered
114 due to the anatomical shape of the proximal tibia. [20] When a medial 3mm gap was present with poor
115 cortical support, the APT component transferred a greater load to the underlying tibial bone than the
116 metal backed design. We have demonstrated that when using APT designs in patients with poor bone
117 quality cortical support may be important.
118 It was these older poor results with the APT that promoted the uptake of modular metal backed tibial
119 components. [2] Many of the suggested benefits of MBT components [2] however have only been been

120 observed in vitro.

121 Recent systematic reviews and meta-analysis however support APT in total knee replacement. [22,23]

122 There is also an argument to use APT components in total knee arthroplasty as a cost reducing

123 measure. Muller & Deehan [5] analysed data from the National Joint Registry of England and Wales

124 (NJR) in 2004 and reported that MBT components were on average £598 more expensive than APT

125 prostheses. They reported that of the 42,791 total knee replacements performed that year only 0.006 %

126 of cases were performed using an APT implant. They extrapolated that if 35,000 of those total knee

127 replacements had been performed using an APT component (over an MBT) then the cost savings

128 would amount to £21 million. The most recent report from the NJR reveals only a modest increase in

129 the use of such components to 0.59% of all total knee procedures.[24]

130 Of the studies in the literature which have specifically addressed the performance of the Depuy PFC

131 APT component [4,5,9,25], none has demonstrated superiority of the MBT over the APT component.

132 Some authors have urged surgeons to exercise caution in using the APT in certain patient groups

133 [26-28] – including those with marked pre-operative deformity / bone defects and in younger patients.

134 Bettinson & Pinder [3] in a recent RCT with a minimum of ten year follow up comparing APT and

135 MBT components found the overall revision rate for the APT in younger patients was extremely low,

136 suggesting that these implants even have a role to play in knee arthroplasty in the younger more active

137 age group.

138 The authors of this study acknowledge that it has several limitations. We agree that limited conclusions

139 can be drawn from such a small case series and that many larger studies alluded to elsewhere in this

140 article have already attested to the efficacy and long term success of the APT component. Furthermore

141 the absence of pre-operative Knee Society Scores did not allow readers to gauge the magnitude of

142 improvement following surgical treatment. Our intention was to summarise our experience with this

143 implant over the long term, summarise the literature regarding it and to continue to raise awareness of

144 its use. The strength and novel aspect of our article however lay in the engineering analysis of our

145 failures which alerts potential users of this implant to its potential pitfalls and to exercise caution and

146 attention to detail when using it.

147 **Conclusion :**

148 The APT component demonstrated excellent clinical and radiographic performance at long term follow
149 up in our study. Furthermore, an engineering analysis of the failures in our case series suggest that
150 careful placement of the implant on the prepared tibial surface may be of greater potential importance
151 than wear debris in determining long term survivorship and has added to our understanding of the
152 surgical technique required when using this implant.

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223 **Figure Legends**

224 **Fig 1** The Depuy cruciate retaining APT component

225 **Fig 2** Cross section of finite element model with idealised elliptical geometry

226 **Fig 3a** Pre-operative antero-posterior radiograph with valgus deformity

227

228 **Fig 3b** Immediate post operative radiograph of same patient with APT component in situ

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230 **Fig 3c** 17 months post-operative antero-posterior radiograph with medial collapse subsidence and

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232 physical deformation of the tibial implant

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234 **Fig 4a** Strain distribution in the proximal tibia for the APT design with a 3mm medial gap

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236 **Fig 4b** Strain distribution in the proximal tibia for the MBT design with a 3mm medial gap

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Fig 1

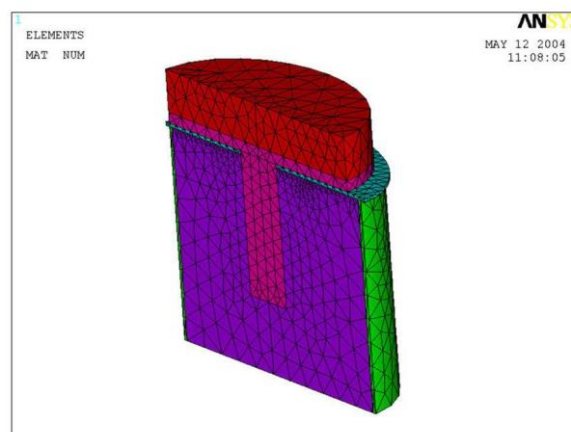


Fig 2

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Fig 3a

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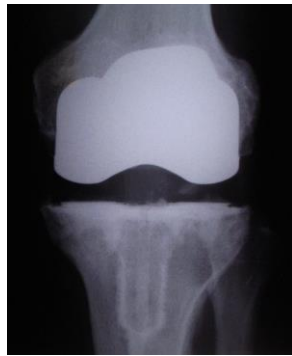


Fig 3b

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Fig 3c

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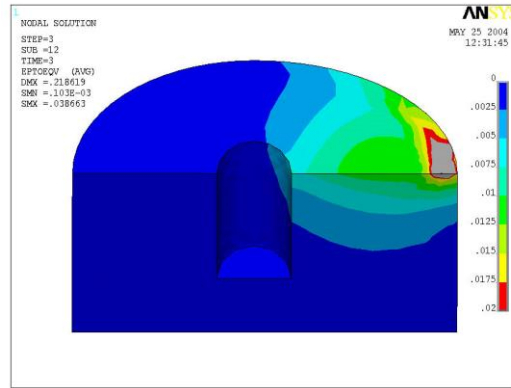


Fig 4a

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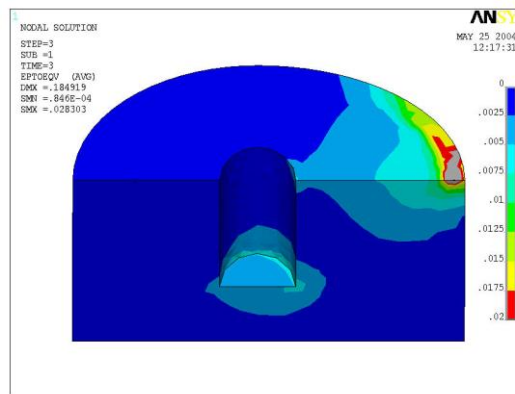


Fig 4b

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