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ORIGINAL STUDY

Age at follow-up and mechanical axis are good predictors of function after unicompartmental knee arthroplasty

An analysis of patients over 17 years follow-up

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Alteration of knee alignment after unicompartmental knee arthroplasty (UKA) influences wear of the prosthesis and progression of arthrosis. Recent reports have questioned the traditional view that undercorrection of the deformity is advisable in UKA. The aim of this study was to analyse whether the location of the mechanical axis at the knee influences the function of the knee after UKA. We analysed the data from 40 patients (54 knees) who underwent UKA over 17 years. The Bristol knee score was maximal when the mechanical axis passed through zones 0 (area of tibial spines) or 1 (inner half of medial or lateral plateau). The average Bristol knee score of those patients was 18% higher than in patients in whom the mechanical axis passed through the other zones ($p < 0.01$, t-test). Using multiple regression analysis to correct for the effect of age on score, a significant relationship was found between the location of mechanical axis and function ($p < 0.001$). Based on these findings, surgeons should attempt to restore the mechanical axis to the centre of the knee during UKA, to help achieve better function.

Keywords : unicompartmental knee arthroplasty ; mechanical axis ; Bristol knee score.

INTRODUCTION

Unicompartmental knee arthroplasty (UKA) has been an option for the treatment of osteoarthritis of a single compartment in the knee for many years. Although UKAs have demonstrated good survivorship at 10 years after implantation, most authors recommend careful selection of patients. Factors such as age, weight, level of activity, accurate diagnosis and alignment influence the outcome (*3,10,12, 14*). The correction of alignment achieved at surgery after careful assessment of the preoperative deformity is the single most important factor that can be controlled by the surgeon during replacement surgery (*11*). The correct postoperative limb alignment to be achieved after UKA is uncertain (*6*). The knee in the normal population is in slight varus alignment (*8*), and this justifies the traditional belief that undercorrection should be recommended to restore the physiological alignment for the individual knee and prevent accelerated wear of the normal compartment (*13*). Accelerated wear of the non arthritic

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compartment and poor results have been reported after overcorrection of alignment (7,12). Similarly severe undercorrection leads to accelerated wear of the prosthesis (2). The influence of alignment on the outcome has led some authors to recommend that the alignment should be restored such that the mechanical axis passes through the centre of the knee (5). The tibiofemoral angle (between anatomical axes) is variable and ranges from 167.5° (varus) to 195.5° (valgus) in the normal population (8). A 5 to 10° valgus correction of the tibiofemoral angle (between anatomical axes) relative to the initial alignment has been reported to correlate positively with survival (14). However, restoring alignment to achieve a particular correction of tibiofemoral angle may not necessarily restore the mechanical axis to the centre of the knee. If the alignment needs to be such that the mechanical axis passes through the centre, then tibiofemoral angle corrections for individual knees have to be calculated in order to restore knee alignment optimally. The aim of this study was therefore to answer two questions :

(1) Do tibio femoral angle (between anatomical axes) and location of the mechanical axis in the knee correlate ?
(2) Does the location of the mechanical axis influence the function of the knee ?

MATERIALS AND METHODS

All living patients with UKA (Miller-Galante Unicompartmental Knee replacement system ; Zimmer, Warsaw, Indiana, USA) performed by a single surgeon (PCM) at Princess Royal Hospital, Telford over 17 years (1989-2006) was reviewed. The prosthesis comprises of a cobalt-chromium-molybdenum femoral component, a titanium tibial base plate and a polyethylene tibial insert. It is a fixed bearing modular system. The jigs used for femoral resection allow the surgeon to choose angles between 3° and 9° of valgus and polyethylene inserts are available from 8 to 14 mm thickness. The surgeon (PCM) set out to achieve undercorrection in order to allow the mechanical axis to pass through the replaced compartment and not the opposite unaffected compartment. It was intended that overcorrection should be avoided.

Forty patients (54 knees) were available for follow-up, of which 51 were medial UKAs and 3 lateral UKAs. Function was assessed using the Bristol knee scores (9). The Bristol knee score assesses pain, deformity and function which includes rising from the chair, walking distance and stair climbing and has a maximum score of 50. Alignment was assessed using standing long leg films.

Radiological analysis

The location in the knee through which the mechanical axis passed was assessed from the long leg views. We used a modification of the method described by Kennedy and White (7), to assess the zone through which the mechanical axis passed (fig 1). The proximal tibial articular surface was divided into zones : 0 (central or area of tibial spines), 1 (inner half of the medial or lateral tibial plateau), 2 (outer half of the medial or lateral tibial plateau), 3 (outside the tibial plateau) (fig 2). Overcorrection was represented by negative values of the above mentioned numbers.

The tibiofemoral angle was measured as the angle between two lines representing the tibial and femoral anatomical axes. The tibial axis was represented by a line joining the centre of the tibial spines to the centre of the talus. The femoral axis was represented by a line joining the mid points between the outer cortices of the femur at the isthmus and ten centimetres proximal to the knee joint line. Valgus alignment was represented by positive values while varus angles were represented as negative values in degrees.

Statistical analysis

To check whether tibiofemoral angle and location of mechanical axis measure the same, single regression analysis was used. Single regression analysis was also used to assess the relation of age, duration of follow-up and alignment based on the mechanical axis or the tibiofemoral angle (between anatomical axes) to function. Multiple regression analysis was used to assess the relation between alignment and function, corrected for age and follow-up. The regression analyses of function with alignment were based on the square of the tibiofemoral angle and the mechanical axis zone. This was done because the plot of Bristol knee score to alignment measures showed a curvilinear rather than a linear spread suggesting a quadratic rather than a linear relationship. A p value less than 0.05 was assumed to denote statistical significance. All statistical analyses were performed using SYSTAT vs. 11 (Systat Software Inc, Point Richmond, USA).

Fig. 1. — Mechanical axis

Fig. 2. — Zones of location of mechanical axis on the tibial plateau (zones on unreplaced compartments represented by negative values).

RESULTS

The mean follow-up was 10.8 years (range 2 to 17). The mean age at follow-up was 71.3 years (range 56 to 81 yrs). The mean total Bristol knee score at follow-up was 43.6 (range 28 to 50). The mean functional score was 16.3 (range 9 to 20). A total of 86% of the patients had a good or excellent total score.

In six knees (two lateral and four medial UKAs), the mechanical axis passed through the non-replaced compartment, due to inadvertent over-correction. In 48 knees (88%) undercorrection was achieved, i.e. the mechanical axis passed through the central zone or inner half of the medial tibial plateau in medial UKAs and the central zone or inner half of the lateral tibial plateau in lateral

Table I. — Correlation of factors to knee scores

Factor	correlation coefficient (R^2)	p value
Age at FU	0.26	< 0.001
Duration of FU	0.00	0.92
Mechanical axis	0.22	0.001
Tibiofemoral angle	0.08	0.11

Table II. — Correlation of alignment to knee scores

Factor	Partial correlation coefficient (R^2)	p value
Mechanical axis	0.39	0.003
Tibiofemoral angle	0.06	0.12

UKAs. In five of these knees, the mechanical axis passed outside the tibial plateau itself (zone 3) suggesting severe undercorrection.

The average tibiofemoral angle (between anatomical axes) ranged from 15.5° valgus to 11.1° varus (mean : 1.11° varus ± 9.2°SD). In patients who had good or excellent function, the tibiofemoral angle (between anatomical axes) ranged from 15.5° of valgus to 8.4° of varus (mean : 2.65° varus ± 5.4°SD). When only the knees with the mechanical axis passing through the central zone was analysed, it was found that the average tibiofemoral angle ranged from 11.1° valgus to 7.3° varus (mean : 3.28° valgus ± 6.8° SD).

There was a moderate correlation between tibiofemoral angle and location of mechanical axis ($r = 0.54$, $p < 0.01$). Of the four single factors analysed (duration of follow-up, age and alignment defined by mechanical axis or tibiofemoral angle (between anatomical axes), only age of the patient and location of mechanical axis significantly predicted the knee score (table I). We did not find a significant relationship between tibiofemoral angle or duration of follow-up and function (table I). Using multiple regression analysis to correct for the effect of age on score, a significant relationship was found between the location of mechanical axis and function ($p < 0.003$; table II). The Bristol knee score was maximal when the mechanical axis passed through zones 0 or 1. The average functional score of those patients was 18% higher than in patients in whom the mechanical axis passed through the other zones (45.8 ± 4.8 vs 38.8 ± 7.0SD, $p < 0.01$, t-test) (fig 3). The relation between mechanical alignment and function (Bristol knee score) was not a linear relation but a quadratic relation.

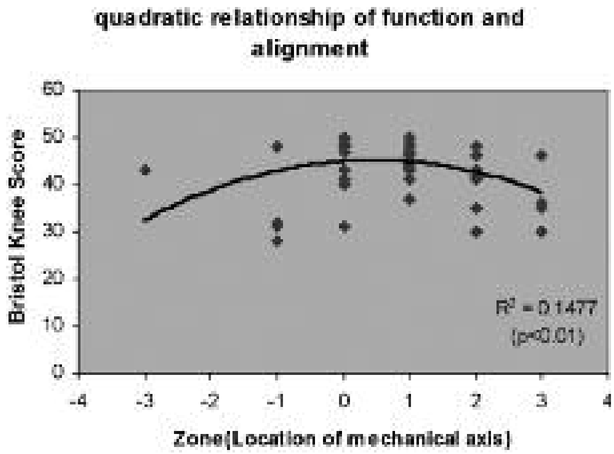

Fig. 3. — Relationship between knee score and zone of location of mechanical axis.

DISCUSSION

The aim of this study was to determine whether the location of the mechanical axis influences function after UKA. The knees in which the mechanical axis was located centrally in the operated compartment had significantly better Bristol knee scores. The location of the mechanical axis appeared to be a predictor of knee function even after the score was corrected for age. Our results show moderate correlation between the two measures of alignment, namely the tibiofemoral angle measured between anatomical axes and the location of mechanical axis at the knee joint. Since the range of acceptable tibiofemoral angles for those knees where the mechanical axis passes through zones 0 or 1 would fall within a limited range, some correlation is to be expected.

Although it is well accepted that alignment influences survivorship, most authors have not found any correlation between function and alignment (*4,7,15*). Our finding of correlation between alignment and function seems to contradict the findings in another study investigating this effect on function (*15*). In that study, no correlation was found between Hospital for Special Surgery scores and alignment, including tibiofemoral angle and location of mechanical axis. However, in our study the relation between mechanical alignment and function was not a linear relation but a quadratic relation. This relation reflects the fact that the Bristol Knee score is maximal when the knee is aligned with the mechanical axis passing through the centre of the knee (zone 0) or through zone 1, and is smaller when the knee is under or overcorrected. The analysis done in the report by Stockelman *et al* (*15*) using Pearson coefficient attempts to identify a linear relationship between variables. This would show as a line on a plot. If the relationship is curvilinear, Pearson's coefficient would fail to establish such an optimal alignment. In our study the relationship is established between the squares of the values of alignment and location of mechanical axis (Quadratic relation).

Although this study found a moderate correlation between location of the mechanical axis and tibiofemoral angle (between anatomical axes) we do not believe that tibiofemoral angle is useful as a substitute for the location of the mechanical axis. In our study, patients who had a knee with the mechanical axis passing through the central zone had a large spread of tibiofemoral angles or anatomical axes (range 11.1° valgus to 7.3° varus, mean: 3.28° valgus ± 6.8° SD). This group included one patient who had a hip replacement and a fixation of a periprosthetic fracture that has left the mechanical axis of the limb passing through the center of the knee but the tibiofemoral angle (between anatomical axes) at 7.3° varus. If this patient was disregarded the tibiofemoral angle (between anatomical axes) measured showed a mean of 5.7° valgus. The large spread of tibiofemoral angles (between anatomical axes) in knees where the mechanical axis passes through the center, can to some extent be attributed to variations in sex and height of individual patients. With such a large spread, defining a specific range for the final tibiofemoral angle (between anatomical axes) to ensure that the mechanical axis passes centrally is difficult. Moreover in order to ensure central alignment of individual knees the correction of mechanical axis needs to be calculated for each knee.

The location of the mechanical axis was not the best predictor of function. Age at follow-up proved to be a better predictor, with patients having a poorer score with increasing age. There was no significant correlation of function with duration of follow- up. In other words, patients who had an implant for a longer period of time did not have a worse score. The combination of the two findings suggests that worsening of the score with age was due to worsening of the general condition with age, rather than worsening of the condition of the implant with time. Although age had a relatively large effect on function, location of the mechanical axis was still a significant predictor after correction for age.

The use of Bristol knee scores in the assessment of UKAs has not been validated, although it has been used by previous investigators (*9*). Bristol knee score when compared to Hungerford, Hospital for Special Surgery and Knee Society scores has been reported to have excellent intra and inter observer reliability (*1*), although for this study all the scores were recorded by a single investigator. The Bristol knee score has a functional component as part of the total knee score. The discrepancies between the total score and the function score would account for variations in patients due to co morbidities even in the presence of good knee function. The effect of co morbidities on function was borne out by the fact that age had a very significant relationship with function even though duration after surgery did not.

Although this study is a single surgeon consecutive series where the same technique and implant has been used in all patients, it has all the weaknesses of a retrospective study. Moreover we did not have sequential radiographs for all the patients analysed. We could not analyse the loss of the correction achieved at surgery over a period of time, which has been reported previously (*12*). Although pre operative alignment views were obtained, they were not used to calculate the correction to have the mechanical axis pass through the centre. There was no attempt to align the knees presented in this series to have the mechanical axis pass through the center of the knee. However, in the light of the findings in this series, we believe that optimization of alignment should be attempted in UKAs.

In conclusion, age at follow-up and location of the mechanical axis in the knee appear to be good predictors of function after UKA. The mechanical axis should pass through the tibial spines or just on the inner half of the replaced compartment. Such an alignment improved Bristol Knee score by approximately 20%. Location of the mechanical axis correlates only moderately with final tibiofemoral angle (between anatomical axes) after surgery.

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