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Posterior cruciate ligament at total knee replacement

ESSENTIAL, BENEFICIAL OR A HINDRANCE?

R. Straw, S. Kulkarni, S. Attfield, T. J. Wilton

From the Derbyshire Royal Infirmary, Derby, England

We report the results of a prospective randomised trial which assessed the role of the posterior cruciate ligament (PCL) following total knee replacement (Genesis I; Smith and Nephew, Memphis, Tennessee). Over a four-year period, 211 patients underwent total knee replacement by the senior author (TJW). They were randomised at surgery to have the PCL either retained, excised or substituted with a posterior stabilised insert. If it was not possible to retain the ligament due to soft-tissue imbalance, it was released from its tibial insertion until suitable tension was obtained. This created a fourth group, those who were intended preoperatively to have the ligament retained, but in whom it was partially released as a result of findings at the time of surgery.

All patients were evaluated using the Knee Society rating system (adapted from Insall). A total of 188 patients (212 knees) was available for follow-up at a mean of 3.5 years after surgery. Preoperatively, there was a varus deformity in 191 knees (90%) and a valgus deformity in 21 (10%).

There were no statistical differences in the knee or function scores or the range of movement between the excised, retained and substituted groups. There were, however, significantly worse knee and function scores in the group in whom the PCL was released (p = 0.002).

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As yet, there is no clear evidence of how best to deal with the posterior cruciate ligament (PCL) at the time of knee replacement surgery. There are four options available to the surgeon. The first is to retain the ligament and to preserve as much as possible of the normal anatomy and function of the knee. Preservation of the ligament is thought to enhance stability and by allowing femoral rollback to improve knee flexion. This increases the mechanical advantage of the quadriceps muscle and prevents unpredictable cyclical loading patterns which may be transferred to the cement-implant and cement-bone interfaces.[1] Some authors also believe that the ligament retains its proprioceptive properties and should therefore be retained,[2] although this has not been confirmed biomechanically. There is also evidence that the PCL is degenerative in most arthritic knees.[3]

The second option is to excise the ligament in order to facilitate the correction of any fixed deformities.[4] This allows more accurate and reliable soft-tissue balancing resulting in improved fixation of the components and offers the surgeon greater freedom to resect more of the proximal tibia if required.

The third option is to substitute the ligament with a posterior stabilised tibial insert. These inserts have a central post which can engage on a femoral cam during flexion, mimic femoral rollback and reproduce near normal kinematic profiles.[5] The central post may also allow some stability in the anteroposterior plane and act as a secondary stabiliser to a varus or valgus stress.[6]

The fourth option is to release the ligament. Some authors believe that this offers a compromise between preservation and excision.[7] Release of a tight ligament may theoretically reduce excessive forces on the patellofemoral joint and postoperative pain, as well as improving knee flexion.

We believe that this study is the first clinical trial to examine the exact role of the PCL after a total knee arthroplasty (TKA) which uses the same articular geometry for the tibial, femoral and patellar components for all groups of patients.

Patients and Methods

TKA was performed on 211 patients with 237 knee replacements by the senior author (TJW) over a period of four years between 1996 and 2000, using the Genesis I system (Smith and Nephew), which has a reported 95% survival at

R. Straw, MRCE, Orthopaedic Registrar
S. Kulkarni, FRCS Orth, Orthopaedic Registrar
S. Attfield, MPhil, CEng, MIMechE Research
T. J. Wilton, MA, FRCS, Consultant Orthopaedic Surgeon
Derbyshire Royal Infirmary, London Road, Derby DE1 2QY, UK.

Correspondence should be sent to Mr T. J. Wilton at 22 Castle Hill, Belper, Derbyshire DE56 4EA, UK.

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Table I. Clinical details of the patients. The mean preoperative tibiofemoral angles are represented as a negative value for a varus knee. Positive angles indicate a valgus deformity. A tibiofemoral angle of 6° valgus was taken as anatomically normal

Group	Number of knee replacements	Gender	Mean age (yrs)	The mean variation from the anatomical tibiofemoral angle (degrees)
Retained	66	37 M 29 F	72.6	-11.8°
Excised	59	32 M 27 F	72.6	-12.2°
Posterior stabilised	42	20 M 22F	74.1	-12.0°
Released	24	12 M 12 F	72.0	-12.1°
Valgus	21	7 M 14 F	74.6	7.8°

Table II. Results for the mean pain score, range of movement and knee score in all groups

Group	Mean pain score	The mean of movement	Patients with extensor lag	Mean knee score
Retained	47.8	100°	3	89.0
Excised	47.0	110°	2	89.8
Posterior stabilised	48.2	110°	1	92.3
Released	38.2	110°	1	83.7
Valgus	48.1	115°	0	92.9

ten years.[8] It was chosen for this study because the articulating geometry of the femur and tibia are the same for both the posterior stabilised and standard designs in the sagittal and coronal planes. The patellofemoral geometry is also the same for both. The only difference in design is the presence of a central post on the modular tibial insert and the posterior stabilised housing and cam in the femoral component.

Preoperatively, patients were randomised for either PCL retention or excision. Those who were randomised to excision were further randomised to receive either a standard tibial insert, or a posterior stabilised tibial insert. For those patients in whom the PCL was retained, but for whom it proved impossible to achieve satisfactory ligamentous balancing at surgery, it was released subperiosteally from its insertion into the posterior aspect of the tibia until its tension was judged appropriate by digital palpation.

All operations were undertaken in laminar-flow theatres and with routine antibiotic prophylaxis. A standard medial parapatellar approach was used for all varus knees and a lateral parapatellar approach for all valgus knees. A 7° valgus femoral cut for valgus knees was routinely used and a 5° valgus cut for varus knees. The patella was resurfaced in all knees using a biconvex component in order to restore patellar thickness. After femoral and tibial preparation, all knees were trialled and balanced using the Monogram Balancer (Howmedica Osteonics, Limerick, Ireland)[9] in both flexion and extension. An attempt was made to achieve perfect ligament tension throughout the functional range of movement.

All patients were followed up for a minimum of one year after operation and were evaluated using the Knee Society Score.[10] All were assessed by the same observer (RS) who was blinded to the type of procedure which had been performed. Case notes and radiographs were not available at the review. This scoring system was chosen because it was thought to be more objective and widely used than others. It is divided into knee and function scores so that increasing age or worsening medical conditions do not have a major impact on the overall score.

Radiological assessment was undertaken pre- and postoperatively by recording the tibiofemoral angles on a weight-bearing, full-length knee radiograph. Postoperatively, measurement allows an assessment of the accuracy of the bony cuts and the quality of the soft-tissue balancing obtained at surgery. The appearance of radiolucencies was not evaluated since the period of follow-up was too short.

Results

Of the 211 patients entered into the study, 188 (212 TKAs) were available for review. Their mean age was 73.2 years (53 to 89). TKA was performed on 194 knees for osteoarthritis and 17 for rheumatoid arthritis; 24 patients had bilateral staged procedures. Eight patients died and 15 were lost to follow-up. The mean follow-up for all patients was 3.5 years (minimum 1 year, range 1 to 6.5). There was deep infection in one patient, who required a two-stage revision procedure. One required further surgery because of loosening of the patellar button. For those patients who were unable to attend follow-up, a review of the clinical notes was undertaken. Their knee replacements were functioning well and they had received no further surgery at the last clinical appointment. All the groups were well matched for age, gender and preoperative deformity (Table I). The patients who were lost to follow-up, but who were reviewed from the clinical notes, were well distributed throughout the groups. However, the released and valgus groups were smaller than the other groups. Preoperatively, 191 knees (90%) had a varus deformity and 21 (10%) a valgus deformity. The small subgroup of valgus knees had a higher proportion of women than the other subgroups. The released subgroup was also smaller but had a similar age and gender distribution as well as a comparable preoperative deformity.

We found no difference in the mean pain score, range of movement, knee score or function score between the excised, retained and posterior stabilised groups. Those patients who underwent a release of the PCL had significantly worse mean pain ($p = 0.03$) and knee scores ($p = 0.002$) than the other groups (Table II) using the Kruskal Wallis non-parametric test. We believe that a 10-point difference in scores can reasonably be regarded as clinically important. Statistically, power estimation gives values from 0.86 to 0.99 depending on the groups compared. All the intergroup comparisons have sufficient power to detect a large effect size. Some may consider a 5-point difference to

Table III. Knee stability for all groups

Knee	Normal anteroposterior stability* (%)	Normal mediolateral stability† (%)
Retained	*54*	*78*
Excised	*51*	*84*
Posterior stabilised	*71*	*88*
Released	*54*	*79*
Valgus	*66*	*66*

*defined as < 5 mm of tibial translation
†defined as < 5° of tibial tilt

Table IV. Postoperative knee function for all groups (mean Knee Severity Scores)

Group	Walking distance	Stair-climbing score	Function score
Retained	38.6	34.6	69.0
Excised	40.8	34.0	73.1
Posterior stabilised	41.7	34.6	74.2
Released	31.7	31.3	62.6
Valgus	38.6	34.7	69.2

be clinically important. If so, our study has sufficient power to demonstrate this difference between the larger groups (those groups with more than 40 cases) with a power estimation of 0.86 to 0.93 depending on the groups compared. It does not have adequate power to demonstrate moderate differences for the released group (24 TKAs) compared to the other groups. This relative lack of power is probably of little importance since we have already demonstrated large statistical differences when comparing the released group to the others. If a two-point difference is considered to be clinically important, our study would require over 350 cases in each group. Clearly, it does not have sufficient power to demonstrate such small differences. Whether such small differences in scores can be interpreted as clinically meaningful is also debatable.

All groups, apart from the released group, reported mean pain scores of over 45 (mild or occasional pain) and excellent knee scores at review. All groups had knee flexion of 100° or more. The retained group had the least amount of knee flexion (mean 100°) with all other groups having a mean knee flexion of 110° or more. Fixed flexion deformity was more common in the released group, being present in three patients out of 24 (12.5%). Valgus knees had the best range of movement with a mean of 115° of flexion and also had the least amount of pain.

Stability was assessed in both the anteroposterior and mediolateral planes. The posterior stabilised knees were most stable with 71% having less than 5 mm of anteroposterior tibial translation and 88% having less than 5° of tibial tilt in the mediolateral plane. The excised group had the greatest anteroposterior laxity with only 51% having less than 5 mm of tibial translation. This laxity was not reflected in the mediolateral plane (Table III).

All groups had similar postoperative, tibiofemoral alignment as judged by full-length, standing, anteroposterior radiographs. The mean tibiofemoral alignment was 6.7° for the retained group, 6.3° for excised, 6.5° for posterior stabilised, 6.5° for released and 7.5° for the valgus groups. In addition, we found no evidence of a cement wedge sign[9] on any of the postoperative radiographs which suggested that adequate soft-tissue balancing had been achieved.

A functional assessment of all the knees was performed (Table IV). The posterior stabilised knees had the highest function score, walking distance and score for stair-climbing, although the scores were not significantly different from those of the retained and excised groups. The excised group had comparable stair-climbing scores to the other groups. Again, the released group performed worst with the lowest function score.

Discussion

We believe that this study is the first to compare the outcome of total knee replacements (TKRs) after retention, excision, substitution and release of the PCL using the same tibiofemoral articular geometry for all replacements. One earlier study[11] compared retention, excision and substitution of the PCL. However, the Press Fit Condylar knee replacement was used for the retained and excised groups and the Insall-Burstein II for the substituted group. The results in this study may have been due to the different replacements rather than the way in which the PCL had been handled. A further study reported the results of excision *versus* retention of the PCL using the same components but found no identifiable differences between the groups.[12]

In our study, the clinical outcome after TKR was similar for those knees in which the PCL was retained, excised or substituted. Interestingly, the valgus knees performed as well as the best varus ones. Of the varus knees, the posterior stabilised replacements had the best knee and function scores as well as the lowest pain scores and the greatest range of movement. The results, however, were not significantly different from those of the retained and excised groups. The least amount of flexion was seen in those knees in which the PCL was retained, which could suggest that the retained ligament was excessively tight in these replacements. Even with an appropriately measured polyethylene insert to balance flexion and extension gaps, the cruciate ligament may be tight and inhibit femoral rollback on the tibia. It has been shown in a cadaver study that release of the PCL can result in improved knee flexion.[13] Although in our study the released group had comparable knee flexion to the other groups, the patients had significantly lower knee and function scores and the highest pain scores.

Release of the PCL was achieved by subperiosteal dissection from the tibia. Although balancing is achieved at surgery, it may be that the ligament can reattach itself to the tibia, or shorten and heal with fibrosis. This may result in either a tight ligament or one which gives inappropriate sen-

sory feedback. An alternative explanation could be that the surgeon's perception of a well-balanced PCL was incorrect. If so, the good scores in the retained group, in which the same assessment for appropriate PCL tension was used, are difficult to explain.

Stability of the knee is an important consideration after replacement. Instability can result in functional difficulties for the patient as well as abnormal loading. This can, in turn, lead to delamination and excessive wear of the polyethylene which may precipitate aseptic loosening. There is, however, little evidence in the literature to suggest that mild laxity can lead to early failure and subsequent revision. Excision of the PCL did not seem to affect the anteroposterior stability. There was little clinical difference between the excised and retained groups. The mediolateral stability also appeared to be unaffected by excision of the ligament. Some authors have demonstrated increased laxity in both planes after excision or release of the ligament.[13,14] We were unable to detect significant differences in laxity between the groups. This may be due to the design of the Genesis prosthesis, which provides mechanical stability in both the anteroposterior and mediolateral planes. Alternatively, it may be that excision of the PCL does not greatly affect stability provided that the remaining soft tissues are satisfactorily tensioned and balanced.

In a recent histopathological study, loss of the structural integrity of the collagen framework of the PCL was found in all patients with joint destruction.[15] Mucoid degeneration of the fibres was frequently seen. Another study revealed that degeneration or rupture of the anterior cruciate ligament strongly reflected the histological state of the PCL.[16] These findings suggest that the retained PCL is structurally and histologically abnormal. There must be doubt as to whether it can ever function properly, if retained. Although these histological studies have demonstrated intact neural tissue within the ligament, it does not follow that this nervous tissue will be functioning normally. This is especially so if the tension in the ligament remains abnormal after TKR.

In summary, this prospective study has shown that release of the PCL can have a deleterious effect after knee replacement and can result in poor performance with more postoperative pain and worse knee and function scores. Retention, excision and substitution of the ligament can all lead to favourable outcomes with little difference between pain, knee or function scores. We have also shown that if the PCL is excised, it is not essential to use a posterior cruciate substituting insert as long as reasonably conforming inserts are used. Long-term follow-up to assess polyethylene wear will obviously be required. Only if increased wear is found after excision of the PCL without substitution could it be concluded that this technique is undesirable.

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