Total knee replacement with intra-articular resection of bone after malunion of a femoral fracture

CAN SAGITTAL ANGULATION BE CORRECTED?

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Intra-articular resection of bone with soft-tissue balancing and total knee replacement (TKR) has been described for the treatment of patients with severe osteoarthritis of the knee associated with an ipsilateral malunited femoral fracture. However, the extent to which deformity in the sagittal plane can be corrected has not been addressed. We treated 12 patients with severe arthritis of the knee and an extra-articular malunion of the femur by TKR with intra-articular resection of bone and soft-tissue balancing. The femora had a mean varus deformity of 16° (8° to 23°) in the coronal plane. There were seven recurvatum deformities with a mean angulation of 11° (6° to 15°) and five antecurvatum deformities with a mean angulation of 12° (6° to 15°).

The mean follow-up was 93 months (30 to 155). The median Knee Society knee and function scores improved from 18.7 (0 to 49) and 24.5 (10 to 50) points pre-operatively to 93 (83 to 100) and 90 (70 to 100) points at the time of the last follow-up, respectively. The mean mechanical axis of the knee improved from 22.6° of varus (15° to 27° pre-operatively to 1.5° of varus (3° of varus to 2° of valgus) at the last follow-up. The recurvatum deformities improved from a mean of 11° (6° to 15°) pre-operatively to 3° (0° to 6°) at the last follow-up. The antecurvatum deformities in the sagittal plane improved from a mean of 12° (6° to 16°) pre-operatively to 4.4° (0° to 8°) at the last follow-up.

Apart from varus deformities, TKR with intra-articular bone resection effectively corrected the extra-articular deformity of the femur in the presence of antecurvatum of up to 16° and recurvatum of up to 15°.

Severe degenerative arthritis of the knee may be associated with long-standing malunion of an ipsilateral femoral fracture. An interval of 32 years between a fracture and the development of symptomatic degenerative change in the knee because of abnormal and excessive loading has been reported.1 When such deformity is present, replacement of the knee may pose a considerable challenge.2,3 Severe extra-articular deformities of the femur may require simultaneous or staged corrective osteotomy,4 but intra-articular resection in conjunction with soft-tissue balancing during total knee replacement (TKR) avoids potential complications related to the osteotomy.5 We previously reported promising results in primary TKR with intra-articular resection to correct an extra-articular deformity in patients in whom the coronal varus deformity in the femur was less than 20° and in the tibia less than 30°.6 However, we have not previously addressed the effect and extent of correction of the deformity in the sagittal plane while performing intra-articular resection during TKR. Lonner and Booth7 considered that extra-articular deformities of less than 20° in the sagittal plane could create a complex imbalance of the collateral ligaments if intra-articular resection of bone and soft-tissue release were performed during TKR. However, there were no data regarding the extent to which the extra-articular deformity of the femur in the sagittal plane could be corrected. Our aim therefore was to evaluate the medium-term outcome of intra-articular correction with soft-tissue balancing during TKR in patients with arthritis of the knee associated with an extra-articular malunion of the femur, and the effect of correction of the deformity in the sagittal plane.

Patients and Methods

Between 1995 and 2006, 16 patients with severe arthritis of the knee associated with an ipsilateral extra-articular malunited fracture of the femur underwent TKR with intra-articular resection of bone and soft-tissue balancing without the use of computer assistance. Two
patients died from unrelated causes leaving 12 available for review. The study was approved by our institutional review board.

There were eight women and four men, with a mean age of 63.7 years (52 to 80) at the time of operation. In eight patients the malunion was located in the middle third of the femur and in five in the distal third (Fig. 1). Additionally, there were nine biaxial and three triaxial deformities. The mean interval from the injury to the operation was 28 years (15 to 40). None of the patients had a deformity seated in the upper part of the femur or had a retained implant in the femur used for fixation of the fracture.

The deformities of the femur in the coronal and sagittal planes were measured by simple angular measurements on anteroposterior (AP) and lateral radiographs (Fig. 1a). The angulations were varus in the coronal plane with a mean of 16° (8° to 23°). In the sagittal plane, seven were recurvatum with a mean angulation of 11° (6° to 15°) and five antecurvatum with a mean of 12° (6° to 16°). We did not perform CT of the hip and knee to measure the rotational deformities. Rotational deformity was determined intra-operatively from the angle between the transepicondylar axis of the femoral condyle and a line perpendicular to the long axis of the tibial shaft (the cutting surface of the tibia). Rotational deformity of the femoral condyle was noted in three femora, 20° of internal rotation in one, 10° of internal rotation in another and 10° of external rotation in the third. Additionally, these three femora had deformities in the coronal and sagittal planes and were considered to have a triaxial deformity.

The mechanical axis of the knee was measured pre-operatively and at the latest follow-up, on a full-length weight-bearing radiograph. The mean mechanical axis in the coronal plane was 22.6° of varus (15° to 27°). The deformity of the knee at the level of the joint line, the anatomical axis, was measured by the angle formed between the long axis of the femur distal to the deformity and the long axis of the tibia on standing AP radiographs. The mean anatomical axis in the coronal plane was 15° of varus (8° to 21°). The sagittal angulation after operation was measured on a lateral radiograph of the femur, by the angle formed between the line perpendicular to the distal cut surface of the femoral condyle and the long axis of the femur proximal to the angulation in the sagittal plane (Fig. 1b). This measurement was very subjective. The mean pre-operative arc of flexion of the knee was 80° (5° to 125°). The mean flexion contracture was 22.7° (10° to 40°) and the mean maximum flexion 97.5° (45° to 125°; Table I).

Operative technique. Our indications for intra-articular joint-line resection and TKR have been previously reported.6 This procedure can be applied if the anticipated line of intra-articular resection through the femoral condyle perpendicular to the mechanical axis of the femur on the pre-operative full-length weight-bearing radiograph does not violate the insertions of the medial or lateral collateral ligament. It can be undertaken if the varus femoral deformity in the coronal plane is 20° or less.6

The knee is exposed through a conventional medial parapatellar incision. An extramedullary guide system is used to cut the femoral condyle when the deformity is in the middle third of the femur or when the intramedullary rod fails to pass through the angular deformity. When an intramedullary guide is used, the entry point is placed on the lateral femoral condyle, since the deformity is varus. The extent of
the lateralisation is based on the pre-operative templating. The extra-articular deformity in the sagittal plane is corrected by using the intramedullary guide, if feasible, or by cutting the femoral condyle, if the extramedullary guide system is used. Rotational alignment is defined by a combination of systems, partly through the cutting plane of the tibia, which is perpendicular to the long axis of the tibia, and also from the tangential line of the anterior surface of the distal femur. The intention is to position the femoral component in a few degrees of external rotation. When the extra-articular deformity is present in the distal femur, the anterior surface of the femur proximal to the angular deformity is used.

According to this approach correct placement of the femoral component in the presence of an internal rotational deformity of the distal femur results in unavoidable notching of the anterior femoral cortex. In our series, two knees (cases 2 and 8) had mild notching. With the use of a wedge cancellous bone graft at the notched area, no peri-prosthetic fractures occurred. In the presence of an external rotational deformity of the distal femur, which occurred in only one patient, no special technical difficulty was encountered in obtaining rotational alignment of the femoral component. All the patients required an extensive medial soft-tissue release using the technique described by Clayton, Thompson and Mack to balance the flexion and extension gap. Additionally, correction of the deformity necessitated more resection of bone from the lateral than from the medial condyle. This procedure involved subperiosteal release of the medial collateral ligament and the tendons of pes anserinus from their tibial insertions. When the varus angulation was 25° or more, the procedure also required release of the soft tissues distal to the middle third of the medial tibial cortex. A lateral retinacular release was required in eight patients. Both cruciate ligaments were excised in every patient and a cemented Advantim posteriorly stabilised implant (Dow Corning Wright, Arlington, Tennessee) was used in all.

Clinical evaluation using the Knee Society rating system was carried out pre-operatively, post-operatively at six weeks and at three, six and 12 months, and annually thereafter. Radiological evaluation was performed using standing AP and lateral radiographs and a skyline view of the patella at each review.

Statistical analysis. The pre-operative and the most recent clinical data including the arc of knee flexion, the Knee Society and function scores, the mechanical axes and the sagittal angulations were compared using the Wilcoxon signed-rank test. The level of significance was set at \( p \leq 0.05 \). All the analyses were performed using the SPSS version 13 software (SPSS Inc., Chicago, Illinois).

Results
The mean follow-up was 93 months (30 to 155). The clinical and radiological data at the last follow-up are shown in Table II. The mean pre-operative Knee Society knee score was 18.7 points (0 to 49) which improved significantly to 93 points (83 to 100) at the last follow-up
The mean pre-operative function score was 24.1 points (10.0 to 50.0) which improved significantly to a mean of 90 points (70 to 100) \((p = 0.002)\). The mean arc of flexion at the last follow-up was 110° (80° to 130°) with an improvement of 35° compared with the pre-operative value \((p = 0.007, \text{ Table } III)\). Two patients (cases 1 and 5) who had only 80° of knee movement post-operatively had a stiff knee pre-operatively. The mechanical axis of the knee had been restored to a mean of 1.5° of varus (5° of varus to 4° of valgus), which represented an improvement of 1.1° \((p = 0.001\). Of the seven patients with extra-articular recurvatum deformities, the mean recurvatum angulation at the final follow-up was 3° (0° to 6°), which was an improvement of 8° \((p = 0.018)\). The five patients with extra-articular antecurvatum deformities had a mean residual antecurvatum of 4.4° (0° to 8°), which represented an improvement of 7.6° \((p = 0.042\); Table III).

No radiolucent lines, loosening of the components at the cement-bone interface, wear of polyethylene or osteolysis around the protheses were observed in any patient. Moreover, no complications such as infection, peri-prosthetic fracture, instability or patellar problems were noted post-operatively.

### Discussion

There are many advantages of using one-stage correction of an extra-articular deformity of the knee with intra-articular resection of bone and TKR, including earlier rehabilitation, no supplementary incision for a corrective osteotomy and no complications related to such a procedure.\(^6\) In our previous series of patients with arthritis of the knee and extra-articular varus deformity of less than 20° in the femur and of less than 30° in the tibia, with intra-articular resection and soft-tissue balancing at TKR we obtained satisfactory results with no complications at a mean follow-up of 38 months.\(^6\) However, at that time we did not consider the extra-articular femoral deformities in the sagittal plane.

Of the seven patients with extra-articular femoral deformities in the previous report, two have since died from unrelated causes. In our current study, we evaluated the remaining four patients from the previous study and eight new patients. All had improvements in the Knee Society knee and function scores as well as increased flexion. Mann et al\(^5\) used the same technique in 11 patients with extra-articular femoral deformity and arthritis of the knee achieving a satisfactory outcome in all at a mean follow-up of two years. Our medium-term results are comparable giving confidence that this technique is biomechanically sound.
TKR in a knee with severe angular deformity is a technically difficult procedure in regard to soft-tissue balancing. In our current study, all the knees were in varus with this element of the deformity confined to the femur. In order to avoid problems balancing the flexion and extension gaps after resection of bone we undertook extensive medial soft-tissue release as described by Clayton et al. We used a constrained knee prosthesis and slightly increased resection of bone from the posterior femoral condyles in addition to about 3° of external rotation of the femoral component in order to match the extension and flexion gaps. Because of extensive correction of the varus deformity and soft-tissue release, lateral retinacular release was often required compared with primary TKR without extra-articular deformities.

Computer-assisted navigation systems have been used in primary TKR for some years. Improvement in the accuracy of bone cuts and restoration of the mechanical axis, and a reduction in blood loss. Although some authors have reported no benefit it clearly provides an alternative approach to TKR in patients with extra-articular deformity and/or retained intramedullary hardware. However, because of the rarity of this situation, there have been only a few reports regarding its use in the treatment of deformities similar to those seen in our patients and similar results were achieved.

Apart from deformity in the coronal plane, the malalignment of the femur resulting from malunion of a fracture may occur in the sagittal plane. Such deformity can increase the complexity of soft-tissue balancing during TKR. The limitation of intra-articular correction which can be undertaken for extra-articular sagittal deformity has not been published. Two previous reports identified a pre-operative sagittal deformity, but did not describe the extent of the correction obtained. At a mean follow-up of eight years, the seven patients with recurvatum improved from a pre-operative mean of 11° to 3° (p = 0.018) and the five with antecurvatum from a pre-operative mean of 12° to 4.4° (p = 0.042).

Our results indicate that intra-articular resection of bone combined with TKR is feasible in osteoarthritis of the knee and can accommodate up to 15° of recurvatum and 16° of antecurvatum of the femur in addition to varus deformities.