Total knee arthroplasty for advanced osteoarthritis in the anterior cruciate ligament deficient knee

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Received: 15 May 2011 / Accepted: 10 June 2011 / Published online: 14 July 2011
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Abstract

Purpose Little is known about intra-operative difficulties and outcomes of TKA in ACL deficient knees.

Methods Fifty-seven osteoarthritic knees (mean age 70 years) with a history of ACL injury underwent posterior-stabilised TKA. Intra-operative findings and results were compared with a matched control group.

Results Difficult tibial exposure and bone loss were noted in the ACL-deficient group leading to one partial patellar tendon avulsion and one femoral condylar fracture. After three years, no infections or revisions occurred. No differences were noted in ROM, IKS knee score (95 ± 6 versus 93 ± 8 , $p=0.1$), IKS function score (83 ± 19 versus 84 ± 16 , $p=0.7$), or radiolucent line presence.

Conclusions Total knee arthroplasty in ACL deficient knees is effective. Difficulty obtaining tibial exposure and posteromedial tibial bone defects should be anticipated. Outcomes are comparable to standard primary TKA.

Introduction

The anterior cruciate ligament (ACL) is frequently injured, with over 200,000 ACL ruptures estimated to occur in the United States annually [17]. Isolated ACL rupture often leads to chronic knee instability [13, 20]. Instability and associated articular cartilage and meniscal damage may contribute to the development of osteoarthritis [3]. A return to high-level activity with an unstable knee following isolated ACL rupture

led to 95% of patients developing meniscal and cartilage damage and progressive osteoarthritis in one series with 35-year follow-up [18]. A similar long-term study documented the presence of degenerative changes in 100% of elite athletes following ACL injury, in spite of having no clinical symptoms of instability [14]. Both cohorts demonstrate at least a 40% risk of undergoing total knee arthroplasty (TKA) within 35 years of an untreated ACL rupture. It is unknown whether ACL reconstruction decreases the risk of development of osteoarthritis [16, 21, 23].

In cases where osteoarthritis develops in an ACL deficient knee, several alternatives have been suggested depending on the clinical and radiological findings. Authors have reported good outcome from isolated ACL reconstruction [22], simultaneous ACL reconstruction and high tibial osteotomy (HTO) [4], simultaneous ACL reconstruction and unicompartmental arthroplasty [6], and isolated HTO [10]. However, in the situation of moderate to severe osteoarthritis, TKA is often the management of choice.

ACL injury and subsequent chronic instability leads to specific intra-articular consequences including anterior tibial subluxation, accelerated posteromedial tibial plateau wear with the development of a dish-shaped defect of the posteromedial tibia plateau (cupula), and progressive varus deformity potentially increasing lateral ligament laxity [5] (Fig. 1). These findings may complicate the performance of total knee arthroplasty in the ACL-deficient knee with chronic instability. To our knowledge, no previous study has reported the intraoperative challenges and surgical outcomes of TKA in this patient population. We postulate that ACL deficiency has a negative impact on the intraoperative management and the postoperative outcome of TKA with respect to ligament balancing, anterior tibial instability, postoperative range of motion, outcome scores, and the need for revision arthroplasty.

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Fig. 1 Anteroposterior and lateral plain radiographs of a right knee with chronic anterior cruciate ligament (ACL) deficiency demonstrating anterior tibial subluxation, the development of a dish-shaped defect of the posteromedial tibia plateau (cupula), and severe medial compartment degenerative disease with progressive varus deformity

Material and methods

Patient selection

After institutional review board approval, patients who underwent TKA between 1990 and 2008 were identified from a prospective surgical database ($n=2,258$). The 255 patients (11.2%) who underwent TKA for osteoarthritis and had a history of ACL injury were selected. All patients had a documented history of ACL ligament injury and anterior instability (positive Lachman or pivot-shift test). One hundred fifty-eight patients who had undergone ACL reconstruction or high tibial osteotomy (HTO) were excluded, as were 40 patients with multi-ligament injured knees. The remaining 54 patients (57 knees) with isolated ACL injury without surgical reconstruction formed the study group. There were 37 right and 20 left knees. Patients who underwent prior arthroscopy were included ($n=3$). The mean length of time from ACL injury to TKA was 34 ± 12 years (range, 15–58 years).

A cohort of control patients ($n=57$ knees) matched for patient age, sex, surgeon, date, and implant with no history of prior knee surgery or ligament injury were randomly selected from our total joint registry. Only patients who underwent primary TKA for the diagnosis of degenerative osteoarthritis were selected to serve as controls. Patients with post-traumatic or inflammatory arthritis were excluded. Pre-operative patient demographics, knee range of motion, International Knee Society (IKS) score [12], radiographic limb alignment as the hip-knee-ankle (HKA) angle, and the anterior tibial translation (as measured on a lateral radiograph during an instrumented Lachman exam) of each knee were measured and recorded for both the study and control groups. No statistically significant differences were noted between the study and control groups with the exception of increased anterior tibial translation in the study group ($p<0.0001$) (Table 1). All patients in both groups demonstrated grade IV osteoarthritis according to the IKDC classification system [8].

Table 1 Pre-operative comparison of the study and control groups

Characteristic	Study group	Control group	Significance
Gender	32 male 25 female	32 male 25 female	$p=1.0$
Age at TKA (years)	70.6 ± 9	73.0 ± 7	$p=0.1$
Body mass index (BMI) (kg/m^2)	27 ± 4	27 ± 3	$p=0.9$
Extension deficit (degrees)	3.5 ± 4	5.0 ± 4	$p=0.4$
Flexion (degrees)	119 ± 7	118 ± 5	$p=0.9$
IKS knee score	43 ± 20	43 ± 17	$p=0.9$
IKS function score	63 ± 17	61 ± 18	$p=0.5$
Hip-knee-ankle (HKA) angle	170 ± 6	171 ± 5	$p=0.4$
Tibial translation (mm)	9.7 ± 8	2.6 ± 6	$p<0.0001$

All data are reported as mean $\pm$ standard deviation

Surgical procedure

All patients underwent TKA with a HLS posterior-stabilised prosthesis (Tornier, St-Ismier, France), which is routinely used in our hospital for all standard TKAs. The tibia was cut with zero degrees of posterior slope but the implant is designed with a built-in posterior slope of 2.3 degrees. The posterior lip of the polyethylene liner is 2.25 mm higher than the deepest point of the liner. All components were cemented. The patella was resurfaced in all cases. The procedures were performed with identical surgical technique in all cases. Intraoperative findings, including tourniquet time, the need for posterior or medial release, the presence of any bony defects and the need for augmentation, the thickness of the polyethylene insert, the use of a stemmed tibial or femoral components, and any intraoperative complications were recorded for all cases.

Outcome assessment

The outcome assessment was performed postoperatively with a minimum two-year follow-up. The need for revision knee arthroplasty surgery, the incidence of infection, knee range of motion, and IKS score (knee score and function scores) were recorded in both the study and control groups. The radiological assessment included anteroposterior, lateral, patellar, and long leg films. The alignment of the knee as the hip-knee-ankle (HKA) angle and the anterior tibial translation were measured. Radiographs were assessed for obvious or

localised polyethylene wear and radiolucent lines using the Knee Society scoring system [7]. Measurements of the implant axes were also obtained.

Statistical analysis

Preoperative and postoperative IKS scores were compared in both the study and control groups using paired *t*-tests. Patient age and BMI, IKS scores and knee range of motion were compared between the study and control groups using unpaired *t*-tests assuming unequal variance. The incidence of radiolucent lines was compared between the two groups using a chi-squared test. Statistical significance was defined as a *p*-value less than 0.05. A power analysis determined that a minimum sample size of 49 patients in each group was required to identify a clinically significant difference of 10 points in the IKS knee and function scores with $\alpha=0.05$ and a statistical power of 80%.

Results

Intraoperative findings

The tourniquet time was 77 ± 19 minutes in both groups ($p=0.9$). A medial release (pie-crusting of medial collateral ligament [MCL]), MCL distal release, or semimembranosus release) was performed in 31 patients in the study group and

Fig. 2 Anteroposterior and lateral plain radiographs of a right knee. The bony defect of the posteromedial tibial was drilled and filled with cement with screw augmentation. An extended tibial stem was used in this case

Fig. 3 Anteroposterior and lateral radiograph of a right knee demonstrating use of a medial tibial metallic wedge to treat a bony defect of the posteromedial tibial. A longer tibial stem was used in this case

35 patients in the control group ($p=0.5$). A posterior capsular release was performed in 13 patients in the study group and 15 patients in the control group ($p=0.7$).

There was significant bone loss of the tibial plateau in three cases in the study group. In each case this was a dish-shaped defect of the posteromedial tibia (cupula). The deficit was drilled and filled with cement with screw reinforcement in two cases (Fig. 2) and one case required a medial tibial metallic wedge (Fig. 3). No bony defects were observed in the control group. Use of a polyethylene insert of increased thickness was necessary in ten cases of the study group and five cases of the control group to obtain appropriate ligament balance ($p=0.2$). A tibial stem 30 mm longer than the standard was used in ten cases of the study group and in five cases of the control group ($p=0.2$).

Two intraoperative complications occurred in the study group related to exposure: one partial patellar tendon

avulsion and one femoral condylar fracture. No intraoperative complications were observed in the control group.

Postoperative outcomes

The mean follow-up after TKA in the study group was 37 months (range, 20–153 months) and in the control group 40 months (range, 19–103 months) ($p=0.4$). No cases of revision or infection were noted in either the study group or the control group. The only postoperative complication occurred in one patient in the study group who presented with a fracture of the patella six months postoperatively. It was managed conservatively. In the early postoperative period, one manipulation under anesthesia was required in the study group for a lack of flexion and none in the control group. At final follow-up, no significant differences in extension deficit or maximum knee flexion were

Table 2 Postoperative comparison of the study and control groups

Characteristics	Study group	Control group	Significance
Extension deficit (degrees)	0.4±1	0.6±2	$p=0.6$
Flexion (degrees)	122±11	120±31	$p=0.3$
IKS knee score	95±6	93±8	$p=0.1$
IKS function score	83±19	84±16	$p=0.7$
HKA angle (degrees)	179±3	178±3	$p=0.2$
Femoral mechanical axis (degrees)	89.5±1.6	88.8±2.3	$p=0.1$
Tibial mechanical axis (degrees)	89.4±2	89.3±1	$p=0.9$
Blackburne index	0.6±0.2	0.65±0.2	$p=0.7$
Tibial slope (degrees)	88.6±2.5	89±2	$p=0.8$
Anterior tibial translation (mm)	0.4±5	0.1±4	$p=0.7$

All data are reported as mean ± standard deviation

Table 3 Tibial radiolucent lines

Group	Anteroposterior view			Lateral view		Incidence	Significance
	Zones 1–2	Zones 3–4	Zone 5	Zone 1	Zone 2		
Study group	10	6	1	2	2	11	$p=0.3$
Control group	7	0	0	0	1	7	

noted between the study group and the control group (Table 2).

Significant improvements in IKS scores were noted in both the ACL deficient (study) group and the control group following TKA. In the study group, the knee score improved from 43 ± 20 preoperative to 95 ± 6 ($p<0.0001$) at final follow-up, and the function score improved from 63 ± 17 preoperative to 83 ± 19 ($p<0.0001$) at final follow-up. In the control group, the knee score improved from 43 ± 17 preoperative to 93 ± 8 ($p<0.0001$) at final follow-up and the function score improved from 61 ± 18 preoperative to 84 ± 16 ($p<0.0001$) at final follow-up. No statistically significant differences were noted in the IKS scores, radiographic alignment, patellar height, or anterior tibial translation between the study and control groups post-operatively (Table 2).

No severe or localised polyethylene wear was observed. Tibial radiolucent lines were observed in 11 cases in the study group and seven cases in the control group ($p=0.3$) (Table 3). Femoral radiolucent lines were observed in eight cases in each group ($p=1$) (Table 4). These lines showed no progression in either group. There was no suspicion of aseptic loosening of either the tibial or the femoral component in any knee.

Discussion

The most significant finding of this study is that a history of ACL injury and chronic anterior instability does not adversely affect outcome following TKA. Using a matched cohort, we found no statistically significant differences in outcome between this patient population and a control group. While this study is appropriately powered to detect clinically significant differences in IKS scores between the study and control groups, it is probably underpowered regarding other outcome measures including failure rates.

This report is the first to report specifically the outcome of TKA performed for osteoarthritis in knees with a history of ACL injury and chronic anterior instability. Although ACL degeneration has been described in association with advanced

osteoarthritic changes [2], this degenerative condition is not associated with significant anterior instability and the specific radiographic changes outlined above that are noted when arthritis develops following ACL injury.

We anticipated increased intraoperative difficulty in cases of ACL-deficient knees. In addition to evaluating outcomes, a goal of this study was to evaluate intraoperative difficulties in these cases. We noted two cases in the study group in which exposure of the tibia was quite difficult, probably due to the presence of the posterior tibial cupula and chronic tibial translation. The surgeon should be aware of the potential difficulties in exposing the tibia. We routinely insert a pin in the patellar tendon when exposure is difficult to avoid patellar tendon avulsion. However, this was not always noted in the surgical report and we were unable to identify all cases where this technique was used. Frequent use of this method may explain why we had only one case of partial patellar tendon rupture when no tibial tubercle osteotomies were performed. We also noted three cases of significant bony defect in the posteromedial tibial plateau. These defects were managed in two cases by drilling the defect and filling it with cement with screw reinforcement [19]. In one case, the tibial bone deficit was larger and required a metallic wedge. Although previously published studies have suggested that chronic ACL deficiency could stretch secondary anterior stabilisers such as the MCL [15], we did not find any evidence of postoperative varus/valgus laxity.

We believe one key to successful long-term outcome following TKA in the ACL deficient patient is the ability of the prosthesis to control anterior tibial translation. The posterior-stabilised design of the implant and the elevated posterior lip of the polyethylene liner contribute to this stabilising effect. These characteristics protect the posterior tibia from abnormal loading that could hasten implant loosening. In this study we noted no difference in post-operative anterior tibial translation between the study and control groups (Table 2). The poor results of unicompartmental knee arthroplasty in ACL deficient knees may be due to the inability of the implant to control anterior translation

Table 4 Femoral radiolucent lines

Group	Zone 1	Zone 2	Zone 3	Zone 4	Zones 5–7	Incidence	Significance
Study group	3	0	0	8	0	8	$p=1.0$
Control group	5	1	2	4	0	8	

[9]. The results of this study should not be extrapolated to cruciate retaining (CR) TKA designs. ACL deficiency has been associated with histological changes in the PCL that may affect its biomechanical properties and thus the kinematics of a CR TKA [1]. Further work is necessary to assess the impact of ACL deficiency on TKA with these prostheses.

One previous study has reported the results of TKA after ACL reconstruction. Hoxie et al. found that ACL reconstruction does not markedly affect the results of TKA [11]. Their reported postoperative range of motion, IKS scores, and rate of revision were similar to those found in our study. The age of their patient group was significantly younger (53 years) at the time of TKA, probably due to our preference to avoid TKA until after age 65.

The strengths of this study are that it is a consecutive series with strict inclusion criteria and prospective data collection with no patients lost to follow-up using a matched control group. The weaknesses are that it is a retrospective review, patient assessments were not blinded, and the follow-up is probably too short to determine whether ACL status affects prosthesis lifespan.

Conclusion

Total knee arthroplasty performed for advanced osteoarthritis in a chronic isolated anterior cruciate ligament deficient knee can be a safe and effective procedure. At the time of surgery, the surgeon should be aware of the potential difficulty in obtaining adequate tibial exposure due to posteromedial tibial wear and the subsequent risk of patellar tendon avulsion or femoral condyle fracture. One must also consider the potential need to address the posteromedial tibial bone deficit. Posterior-stabilised total knee arthroplasty in the ACL deficient knee has clinical and radiological outcomes comparable to primary TKA performed for degenerative osteoarthritis.

Acknowledgement The authors thank Camdon Fary, M.D. for assistance in preparation of the manuscript.

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