Minimally Invasive Total Knee Arthroplasty: A Comparative Study to the Standard Approach

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Abstract

Background: Minimally invasive surgery has gained popularity over the past several years. Early results have shown better functional outcome with early recovery and rapid rehabilitation. Aim: Evaluation of the short-term clinical and functional outcome of minimally invasive surgery total knee arthroplasty (MIS-TKA) compared with the traditional total knee arthroplasty (TKA). Materials and Methods: During 2009, all cases scheduled for primary TKA through the modified mini-mid-vastus approach (MIS group) were studied. This group included 40 knees and was compared to a cohort control group of similar number of patients (40 knees) that underwent the procedure through the standard conventional technique (standard group). Results: Patients in the MIS group showed significant decrease in postoperative pain, blood loss in first 24 hours, and in hospital stay. Furthermore, they achieved motion considerably faster than the standard group with earlier return of quadriceps function and greater early flexion. Conclusion: This study proved that MIS-TKA has the ability to couple the benefits of less invasive surgical approach.

Keywords: Minimally invasive surgery, Total knee arthroplasty, Standard approach in Total knee replacement

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Introduction

Total knee arthroplasty (TKA) has been a very successful procedure in the treatment of end-stage arthritis of the knee. Long-term results for pain relief and functional improvement have been excellent.[1-6] However, this procedure traditionally required an extensive approach (20-25 cm) with an arduous recovery period.[1,7] Also, some patients may end with permanent quadriceps weakness.[7]

The mini-incision technique can be viewed as part of a continuum in the transition from classic, more extensive exposure to the true quadriceps-sparing minimally invasive surgery total knee arthroplasty (MIS-TKA).[8-12] The proposed benefits of minimally invasive approach include: improved gain of early flexion, decreased pain scores and use of analgesics, improved quadriceps function, decreased blood loss, shortened length of hospital stay, cosmetically better smaller incision, early recovery and rapid rehabilitation.[1,8,13-15]

The purpose of this study is to evaluate the short-term clinical and functional outcome of MIS-TKA compared with conventional TKA, also to assess some of the predictors of the long-term outcomes such as radiographic alignment of components and knee stability.

Materials and Methods

All cases admitted to Makassed General Hospital with a diagnosis of primary osteoarthritis during 2009 and those which underwent TKA were studied. No exclusions based on Body Mass Index (BMI) or preoperative deformities were done. Only one patient with hemophilic arthropathy was excluded due to severe limitation of range of motion (ROM) (<30°) that necessitates V-Y flap of the quadriceps muscle. The group in which modified mini-mid-vastus approach[16] (MIS group) was used included 40 knees (34 patients).
These patients were compared to 40 cases of TKA done during the same period using the standard medial parapatellar approach (standard group). All TKA procedures were performed by surgeons with similar level of training.

The study protocol was approved by hospital Institutional Review Board.

Data was collected from inpatient hospital files as well as outpatient hospital files during the follow-up visits at 3, 6 and 12 weeks postoperatively.

Preoperative data included: age, sex, weight, height, BMI, preoperative ROM, preoperative deformity and alignment, preoperative knee functional and objective society scores.[16]

Postoperative data included: length of incision in extension, tourniquet time, amount of blood loss (loss in wound drains in first 24 hours), length of hospital stay, postoperative non-assisted straight-leg raising (SLR), postoperative passive flexion on third postoperative day, postoperative pain as evidenced by visual analogue pain score on first postoperative day and amount of analgesic narcotic drugs (Pethidine) received by the patient in the first 48 hours postoperatively. In addition, postoperative knee functional and objective society scores including postoperative range of motion ROM at 3, 6 and 12 weeks were also recorded. Femoral and tibial component alignment on standing AP and lateral X-ray views according to the Knee Society TKA roentgenographic evaluation form,[17] and complications were also recorded.

**Surgical approaches and instrumentation**

The MIS mid-vastus approach[1,16] [Figure 1] was done with an anterior midline skin incision from 2 cm above the superior pole of patella and 2 cm distal to the joint line (just medial to the tibial tubercle), a medial sub-fascial flap was developed to expose the broad insertion of the vastus medialis muscle. With the knee in flexion, the vastus medialis obliquus (VMO) muscle was divided full-thickness in line with its muscle fibers, starting at the superomedial corner of the patella and proximally extending for only 2 cm (quadriceps snip). The medial retinaculum and medial capsule at level of patella and patellar tendon were incised leaving a rim of soft tissue attached for repair at the end of the procedure. The patella was displaced laterally but was not everted (subluxation). The knee was flexed and extended as necessary to move the soft tissue (mobile window) to allow proximal or distal exposure.

In the standard group, a median parapatellar incision was made extending from the tendinous insertion of the quadrates femoris on the patella to the medial aspect of the tibial tuberosity. The knee was flexed after patellar eversion.

For both groups, femoral cuts were performed using intramedullary guiding system with anterior referencing for placing cutting jigs. The goal was to place the femoral component in 5º valgus as referenced to the femoral intramedullary axis in the coronal plane and at 180º as referenced to the femoral intramedullary axis in the lateral plane. An extramedullary guide was used for placement of the tibial resection guide. The goal was to resect the tibia at 90º to its anatomical axis in the coronal plane, and with a 3º down slope in the lateral plane.

The patella was not resurfaced (non-prosthetic arthroplasty) and this does not add to the difficulty of exposure. Patellar tracking was tested. All femoral and tibial components were fixed in place using cement. Surgeries were done under either spinal anesthesia or para-vertebral block anesthesia with sedation. Postoperatively, a negative pressure drain was used for 24 hours. Deep vein thrombosis (DVT) prophylaxis was given to all patients using low molecular weight heparin. For the MIS-TKR procedures alignment guides and cutting blocks for the tibia and femur were versions of standard instrumentation that were reduced in size, and geometrically changed to facilitate placement within a smaller soft tissue envelop (Zimmer MIS instrumentation, Zimmer, Warsaw, IN). Implants used were Zimmer, NexGen®, Legacy Posterior Stabilized (LPS).[18]

For both groups mobilization began on the first postoperative day assisted by a physical therapist with full weight bearing on the operated leg using a knee immobilizer for support and a walker for balance along with active, passive, and active-assisted ROM exercises. No continuous passive motion (CPM) machine was used. Postoperative pain protocol was as follows: IV
Perfalgan (Acetaminophen) 1g every 6 hours and Dolosal (Pethidine) 1mg/kg every 6 hours for severe pain.

**Statistical analysis**

Statistical Analysis: Statistical Package for the Social Sciences (SPSS) version 10.1 was used for descriptive statistical analysis. *t*-test was used to assess significant difference among all numerical parameters of the study within the two surgical groups (*P*<0.05) was considered significant.

**Results**

The MIS group had a mean length of incision in extension of 10.5 cm (±1.55 cm). The standard group had a mean length of incision of 18 cm (±1.57 cm). The tourniquet time was greater in the MIS group (80±9 minutes) than in the standard group (67±9 minutes) (*P*<0.0001). The mean total blood loss (from the drains in the first 24 hours) was greater (*P*<0.001) in the standard group (374±113 ml) than in the MIS group (281±127 ml). The average length of hospital stay was less (*P*<0.0001) in the MIS group (5.2±1.5 days) than in the standard group (7±1.8 days).

Postoperative pain on postoperative Day 1 was significantly lower (*P*<0.001) in the MIS group than in the standard group. In addition, the average amount of narcotic consumption in the first 48 hours (Pethidine 1mg/kg) was significantly lower in the MIS group than for the standard group. Active straight-leg raise was achieved significantly quicker (*P*<0.001) in the MIS group at than in the standard group. Furthermore, on third postoperative Day 3 the patients who had mini-incision procedures had significantly better (*P*<0.0001) flexion than patients who had the standard procedure with a mean difference of 16°.

MIS Patients had significantly higher (*P*<0.0001) ROM at 3, 6, and 12 weeks of follow up [Figures 2 and 3].

Likewise, Knee Society function and objective scores were significantly higher in the MIS group at 3, 6 and 12 weeks postoperatively (*P*=0.0001) [Figure 4]. Neither group had major complications (deep infections, hematomas, clinically evident deep vein thromboses, or major cardiopulmonary complications). One lateral retinaculum release was done in MIS group (2.5%) and none in the standard group.

Femoral and tibial implant alignments were measured in both sagittal and frontal planes. There were no significant differences in component alignments between the groups, with excellent position of the components in both groups. Optimum tibial alignment was considered to be 90°±2° in the coronal plane and 87°±2° in the sagital plane. Optimal femoral alignment was considered to be 95°±2° in the coronal plane and 180°±2° in the sagital plane. Likewise, excellent stability to varus and valgus and antero-posterior stresses was found in both groups, with no significant difference between them.

**Discussion**

For the last 30 years TKA has been done through the standard 20-25 cm approach which entails disruption.
of the quadriceps mechanism, eversion of the patella, dislocation of tibiofemoral joint and interruption of suprapatellar pouch.\textsuperscript{[8]} The ultimate results of this technique have been excellent with 10 year survival of more than 90%.\textsuperscript{[2-7]} However, obtaining these results with this technique may not be that easy for patients and often the recovery period is long, arduous and painful.\textsuperscript{[1,7,8]}

Satisfactory radiographs and long-term survivorship do not address patients' satisfaction issues.\textsuperscript{[17,19-23]} Likewise, Trousdale et al.,\textsuperscript{[23]} showed in a study that two of the greatest concerns for patients before undergoing total hip or total knee arthroplasty were pain and length of recovery.

Many Aspects of traditional TKA may contribute to the difficult prolonged rehabilitation and less-than ideal functional outcome. These include extensive quadriceps damage and denervation which may be permanent and prolonged patellar eversion which causes stretching of the muscle.\textsuperscript{[7]} Patient demand, possible decreased costs, and the development of new instruments and techniques all have contributed to the increased focus on MIS-TKA.

MIS is not just a smaller skin incision (<14 cm) but a continuum of the standard technique with many evolutionary features.\textsuperscript{[7]} The most important of these features are: quadriceps-sparing approach with less soft tissue dissection, lack of patellar eversion, and no tibiofemoral joint dislocation.

The main findings of this study were the significant reduction in postoperative pain, blood loss, and hospital stay with significant greater values of regain of passive flexion and earlier return of quadriceps function as evidenced by earlier straight-leg raising (SLR). Moreover, during all stages of follow up significantly better ROM and higher functional and objective knee society scores were noted in the MIS group.

A reduction in postoperative pain was a major finding in the MIS group. Verbal analog scale (VAS) was significantly lower in the first postoperative day, as was the amount of narcotic consumption in the first 48 hrs ($P<0.0001$). This could be explained by the reduced amount of soft tissue dissection. Another beneficial effect noted in the MIS group was the rapid regain of flexion after surgery. Most of MIS patients achieved more than 90° of flexion by the third postoperative day. The difference in passive flexion between both groups was 16° in favor of the MIS group ($P<0.001$). This may be related to the less injury of quadriceps muscles.\textsuperscript{[23-26]} This, in turn, allowed the patients of this group to reach their functional milestones faster and permitted them to have earlier hospital discharge by an average of two days.

Blood loss was significantly greater in the standard group as evidenced by more amount of blood accumulated from drains in the first 24 hrs (374 cc versus 281 cc). This may be related to the more extensive damage to the vascular anastamosis around the knee.

The improved postoperative ROM and higher knee scores were mainly due to intact extensor mechanism and less stretching of the patellar tendon.\textsuperscript{[23-26]} We assume that bias is negligible regarding this issue as no difference was present in patients of the both groups as regard preoperative ROM, BMI, postoperative rehabilitation, and pain control protocols.

All these beneficial effects would be underweighted if the MIS approach resulted in implant mal positioning. We found no difference between groups as regard to radiographic positioning of components in either antero-posterior or lateral planes. Excellent ligament balancing in both sagital and coronal plane was found between the two groups. This may be due to the use of the specialized instruments contributed to the accurate alignment described in this study.

Our results were comparable to those few studies published about MIS-TKA benefits as it allows early functional recovery without sacrificing radiographic positioning of the implants.\textsuperscript{[1,3,13,27]}

In conclusion, this study has proved that MIS-TKA has the ability to couple the benefits of less invasive surgical approach without compromising the long-term established success of conventional TKA. However, the concept of MIS-TK should be evolutionary and not revolutionary. A good general rule is that incision should be as small as possible but as large as necessary to ensure the best outcome.

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