

# Rapid Ambulation and Range of Motion after Minimally Invasive Total Knee Arthroplasty

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The authors evaluated the intraoperative data and early clinical results of 22 minimally invasive mini-incision total knee arthroplasties (mini-incision TKAs) performed between October 2002 and September 2003. Results were matched with 22 patients who underwent standard TKA in the same period. At a minimum 12-week follow up, results comparing the mini-incision TKA group and the standard TKA group were evaluated as follows: The average operative time was 137.1 vs 115.8 min ( $p=0.02$ ), the average wound length was 9.4 vs 13.7 cm, the average blood loss was 456 vs 512 ml ( $p=0.14$ ) and the number of patients who could start to walk on postoperative day one was 17 vs 2. On postoperative day one, 82% of the mini-incision TKA group could do active knee extension meanwhile none of the standard group could. Postoperative pain score was not different at 24 hours or 48 hours. At 2 and 6 weeks, the mini-incision TKA group had less pain with significant difference ( $p=0.002$  and  $p=0.002$ ). The postoperative range of motion in the mini-incision group was also significantly improved at 2 weeks ( $p=0.03$ ). However, pain and range of motion were not different in both groups after 12 weeks. Early results of mini-incision TKA accelerated patient postoperative activity, ambulation and range of motion.

**Keywords :** Minimally invasive, Mini-incision, Total knee arthroplasty, Technique

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Following the satisfactory early results of minimally invasive mini-incision total knee arthroplasty (mini-incision TKA) reported by Tria in 2002<sup>(1)</sup>, this new surgical technique which minimizes extensor mechanism injury has been of much interest to orthopaedic surgeons all over the world. Although the procedure is somewhat in the phase of instrument developing, following the principle of surgical technique as classically described by Insall et al<sup>(2,3)</sup> in the mobile skin window can provide successful result and reproducible procedure<sup>(4)</sup>. As the pioneer surgeon<sup>(4)</sup> advocated using a standard knee implant to eliminate prosthetic survivorship concern, it is possible for interested surgeons to perform this procedure with some modification of the standard instrument set<sup>(5)</sup>. Besides the surgical technique itself, specific anesthetic method and postoperative pain control also have important roles on the early postoperative ambulation of the minimally invasive arthroplasty as described for minimally invasive total hip arthroplasty<sup>(6)</sup>.

The purpose of this study was to report early results of mini-incision TKA in terms of intraoperative

data, early postoperative ambulation and complications related to this surgical technique.

## Material and Method

Between October 2002 and September 2003, the authors performed 22 mini-incision TKAs in 22 patients. Patient selection criteria for mini-incision TKA included advanced knee disease with no or stable medical condition, within 10-degree knee deformity in all planes and no previous major knee operation. The anesthetic method selected for each patient was according to the anesthesiologist's preference. Among 22 patients, 12 had spinal analgesia, 6 had general anesthesia and 4 had epidural analgesia. The average age was 66 years (range, 57-81 years). The average preoperative Knee Society score was 37.5, (range, 24-46). At the same period, 22 patients who underwent standard TKA were matched with each patient in the mini-incision group according to, anesthetic method, age, deformity and medical condition, respectively. Standard posterior stabilized knee implant (NexGen LPS, Zimmer, Warsaw, IN, USA) was used in both groups of patients. No specific postoperative pain control was used. Intraoperative data, immediate postoperative data and ambulation ability of both groups were recorded according to the medical file. Pain scores, range of motion and radio-

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graphic measurement of both groups were recorded according to the mean of data from 2 independent observers (ST and SN). At the minimum 12-week follow-up, all data were compared between both groups.

### ***Surgical technique of Mini-incision TKA<sup>(7)</sup>***

Surgical technique was modified from the standard technique following the principle of soft tissue balance and bone cut. A 9-10 cm incision is started from the medial side of the superior pole of the patella to 1-2 cm distal to the tibial joint line. Arthrotomy is performed in line with the skin incision and only 2-3 cm of quadriceps tendon is splitted (Fig. 1a). The proximal tibia is exposed from the medial side along the posteromedial corner. The collateral ligaments are then provisionally balanced until neutral mechanical axis in extension is achieved. The patella is shifted to the lateral side of the femur and distal femoral cut is performed with modified intramedullary femoral cutting guide allowing for distal femoral valgus cut of 6 degrees (Fig. 1b). Cutting both condyles is made inside the mobile skin window from the medial side towards the lateral side with 30-45 degrees of knee flexion.

The unicompartmental extramedullary tibial cutting guide is then placed on the anteromedial side of the tibia. The depth and slope of the proximal tibial bone cut is measured using the depth gauge (Fig. 1c) and the wedge in the same fashion as the technique of standard TKA. Bone cut is done with the knee in 20-30 degrees of flexion. After distal femoral and proximal tibial bone cut, an approximately 20-mm space extension is tested with a spacer (Fig. 1d) and provisional knee alignment in extension is evaluated. The modified posterior referencing system femoral sizing is used to select the matched size. Epicondylar axis as described by Berger<sup>(12)</sup> is determined by palpation of the bony landmarks inside the mobile skin window (Fig. 1e). Anteroposterior axis<sup>(13)</sup> is used to confirm whether both axes are in agreement. The femoral AP cut is made using the modified AP cutting guide (Fig. 1f). The flexion and extension gaps can now be balanced and adjusted as necessary (Fig. 2a). After soft tissue balancing and knee alignment is satisfactory, the femoral chamfer and box cut is performed using the modified finishing guide (Fig. 2b). To provide more room, the patella surface can be prepared at this stage. With the knee in hyper-flexion and external rotation, the matched tibial sizing and positioning are performed (Fig. 2c). The trial components are inserted and tested for mechanical alignment and stability along the full range of motion (Fig. 2d), as well as tracking of the patella.

All surfaces are then lavaged and cleaned. Components are cemented starting with the tibial tray, the patella component and the femoral component (Fig. 2e). The selected polyethylene is inserted finally. The bleeding points are electrocauterized and the drain is placed before closing the wound (Fig. 2f).

### ***Statistical analysis***

Paired t-test was used to evaluate the operative time, collected blood in the drain, patient numeric pain scores at 24 hours, 48 hours, 2 weeks, 6 weeks and 12 weeks as well as postoperative range of motion. The p values < 0.05 were considered significant. Number of patients who could have early ambulation was described in percentage.

## **Results**

### ***Mini-incision TKA***

The average operative time was 137.1 min. The average wound length was 9.4 cm (Fig. 3a, 3b). The postoperative blood loss averaged 456 ml. Patient numeric pain scores at 24 hours, 48 hours, 2 weeks, 6 weeks and 12 weeks postoperatively averaged 5.1, 3.5, 1.6, 1 and 0.5, respectively. Seventeen patients could walk with a walker the next day. The rest could walk on the second day (Fig. 4). Eighteen patients could straighten their knees on the first day. Regarding postoperative length of stay, 9 patients went home on the third day, 10 on the fourth day and 3 on the fifth day (Fig. 5). The average postoperative range of motion at 2 weeks, 6 weeks and 12 weeks was 5-115, 0-130 and 0-131 degrees. There was 1 patient with prolonged wound drainage. There was no radiographic mal-alignment of implant position; however, 2 patients had mild anterior femoral notching due to posterior placement of the femoral component.

### ***Standard TKA***

The average operative time and wound size were 115.8 min and 13.7 cm, respectively. The average postoperative blood loss was 512 ml. Postoperative pain scores at 24 hours, 48 hours, 2 weeks, 6 weeks 12 weeks were 5.5, 3.9, 3.3, 2.2 and 0.4, respectively. Two patients walked the next day, 10 patients on the second day, 9 patients on the third day and 1 patient on the fourth day (Fig. 4). None could straighten the knee the next day. The average length of stay after surgery was 5 days (range, 4-7 days) (Fig. 5). The average postoperative range of motion at 2 weeks, 6 weeks and 12 weeks was 0-106, 0-127 and 0-129 degrees. There was no complication as well as radiographic mal-alignment of implant position.



**1a**



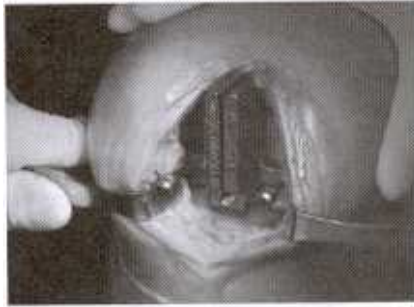
**1b**



**1c**



**1d**



**1e**



**1f**

- Fig. 1a A 9-cm skin incision and only 2-3 cm of the quadriceps tendon is split  
 Fig. 1b The distal femoral cut is performed with modified intramedullary femoral cutting guide  
 Fig. 1c The tibial cut is performed with the unicompartamental extramedullary tibial cutting guide  
 Fig. 1d The extension space is tested with 10-mm spacer for full extension and neutral mechanical alignment  
 Fig. 1e The epicondylar guide is placed along the transepicondylar axis  
 Fig. 1f The femoral AP cut is made with modified AP cutting guide



**2a**



**2b**

- Fig. 2a The flexion gap is tested for stability with the same spacer used for the extension gap  
 Fig. 2b The size-matched chamfer cutting guide is inserted and bone cut is done



2c



2d



2e



2f

- Fig. 2c The tibial bone is prepared for appropriate size tibial component
- Fig. 2d Trial components are provisional inserted with trial plastic. Stability and the ROM are finally tested
- Fig. 2e All components are inserted with cement
- Fig. 2f Skin incision is closed



3a

3b

Fig. 3a,3b Preoperative appearance and postoperative incision scar of patients underwent mini-incision TKA

**Discussion**

Minimally invasive technique for knee arthroplasty was first introduced by Repecci<sup>(8)</sup> for unicompartmental knee arthroplasty (UKA). The minimally invasive UKA (MIS-UKA) surgical approach was modified from the standard medial parapatellar arthrotomy, which needed eversion of the patella and division of the quadriceps tendon as done in TKA, to be a shorter incision without patella eversion or quadriceps tendon division. According to this author, the MIS-UKA can be performed with an 8-cm long incision in combination with a full range of specifically designed instruments. This tech-

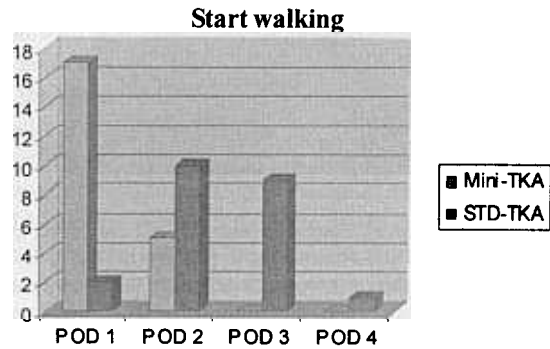


Fig. 4 Graph comparing postoperative day (POD) which patient start walking between mini-TKA group and standard TKA group

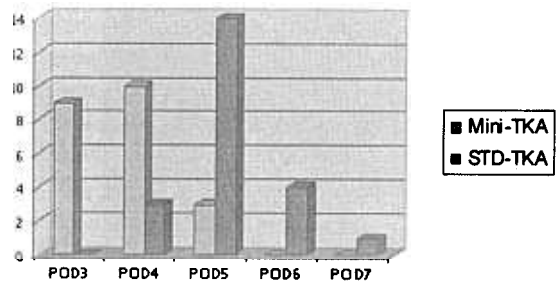


Fig. 5 Graph comparing postoperative day (POD) which patient was discharged to home between mini-TKA group and standard TKA group

**Table 1.** Comparison of results of Mini-TKA and Standard TKA

Parameters	Mini-TKA		Standard TKA		p value
Average op time (min)	137.1	100 to 190	115.8	70 to 180	0.02*
Average wound length (cm)	9.4	8 to 12	13.7	12 to 17	
Average postop blood loss (ml)	456.0	250 to 730	512.0	380 to 720	0.14
Average numeric pain score					
24 hours postop	5.1	2 to 8	5.5	1 to 9	0.5
48 hours postop	3.5	2 to 5	3.9	1 to 9	0.36
2 weeks postop	1.6	0 to 3	3.3	2 to 8.5	0.002*
6 weeks postop	1.0	0 to 3	2.2	1 to 5	0.002*
12 weeks postop	0.5	0 to 3	0.4	0 to 1	0.8
Patient recovery (number)					
Start walking on POD 1	17	77%	2	9%	
Start walking on POD 2	5	23%	10	45%	
Start walking on POD 3	0	0%	9	41%	
Start walking on POD 4	0	0%	1	5%	
Active knee extension (number)					
Within 24 hours postop	18	82%	0	0%	
Average range of motion					
2 weeks postop	5-115		0-106		0.03*
6 weeks postop	0-130		0-127		0.08
12 weeks postop	0-131		0-129		0.19

Note POD; post operative day

nique, addressing one compartment of the knee with less invasion of the extensor mechanism, could provide better immediate results in terms of postoperative pain, blood loss, early ambulation and patient satisfaction. Further more, this new surgical technique yielded comparable long-term results to those done with the standard technique<sup>(9)</sup>. Recently, Price and et al<sup>(10)</sup> confirmed that implant position after MIS-UKA was accurate with the use of new designed guidance instruments inside the small mobile skin window.

In the year 2001, Tria<sup>(4)</sup> demonstrated that with concepts of MIS-UKA approach, TKA could be performed successfully and his early results tended to be similar to that of MIS-UKA. According to Tria's study<sup>(1)</sup>, some restrictive indications were used, which were good medical health, within 10-degree knee deformity in all planes, less than 180 lb and good bone quality. The surgical approach was recommended to begin from the superior pole of the patella to 1-2 centimeter below the tibial joint line. After 2 primary bone cuts, the space in full extension should be about 20 millimeters to provide room to work on further steps.

According to Tria's series, the operative time of MIS procedure was twice as long as the standard procedure and the blood loss was half of the standard procedure. In the present series, the operative time of mini-incision technique was 20% (average 21 minutes) longer than that of the standard technique with significant difference ( $p=0.02$ ). However, the average blood

loss of the mini-incision group was not significantly different ( $p=0.14$ ) from the standard group which was different from the result of Tria's study. The authors believe that differences between surgery time and blood loss were related directly to the wound size. The longer operative time was closely related to the too small wound size to provide adequate access for instrumentation. In addition, patellar baja and large size patella were major difficult factors to accomplish good exposure. Although the average hospital stay in the present series was longer than that of Tria's, all of the presented patients were sent directly home.

Specific anesthetic method and postoperative pain control were preferred to nonspecific anesthesia and pain management because it was concerned as a part of successful minimally invasive surgery in arthroplasty<sup>(6)</sup>. Narcotics which may cause dizziness, nausea and vomiting can delay the patient's early ambulation, were not recommended for this new technique. As the majority of the patients in the present study had narcotics for pain control, it is possible that the side effect of high dose of narcotics on postoperative day 0 had a role on this day's ambulation. Although postoperative numeric pain scores of both groups were not significantly different at 24 hours ( $p=0.50$ ) and 48 hours ( $p=0.36$ ), ambulation was much different. This could be the effect of minimally invasive technique to minimize muscles and tissue injury. The authors believe that the surgical technique itself was the key factor to

provide significant pain relief from 2 weeks ( $p=0.002$ ) to 6 weeks ( $p=0.002$ ), faster power of knee extension, faster ability to walk and significant improvement of range of motion at 2 weeks postoperatively ( $p=0.03$ ).

Although all the knees in both groups had good postoperative alignment in frontal and sagittal plane, the authors realized that 2 cases with femoral notching were related to poor visualization of the anterior cortex of femur and error in femoral antero-posterior cutting guide positioning. To accomplish a long-term successful TKA<sup>(13)</sup>, it is mandatory that surgeons must have correct bone cut, good implant position and knee alignment even though it may need a longer incision. In difficult cases, it is wiser to keep a good visualization with larger wound size than to continue to complete the surgery with limited incision. The authors agree that catastrophic pitfalls after less invasive surgical technique will deteriorate the results that the surgeons would expect. However, after the adequate surgeon's learning curve and the development of instruments and the computer navigation system<sup>(14)</sup>, minimally invasive total knee arthroplasty may be widely recommended instead of the standard procedure.

## Conclusion

The present preliminary study demonstrated that patients with minimally invasive mini-incision TKA had better clinical results than those with standard TKA in terms of wound size, blood loss, postoperative knee pain, walking ambulation and length of hospital stay. However, the early experience in a small number of patients with this new technique tended to have longer operative time and less precision of implant position. With the use of well developed guidance instruments and modular prosthesis, this new technique would provide more implant accuracy and shorter operative time.

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การเดินและการงอข้อเข่าที่เร็วขึ้นหลังการผ่าตัดเปลี่ยนข้อเข่าเทียมด้วยวิธีเนื้อเยื่อบาดเจ็บน้อย

อารี ตनावลี, สาธิต เทียงวิทยาพร, สิทธิชัย งามอุโฆษ

คณะผู้วิจัยศึกษาผลเบื้องต้นของการผ่าตัดเปลี่ยนข้อเข่าเทียมด้วยวิธีเนื้อเยื่อบาดเจ็บน้อย (mini-incision TKA) ในผู้ป่วยจำนวน 22 ราย ซึ่งได้รับการผ่าตัดระหว่างเดือนตุลาคม พ.ศ. 2545 ถึงเดือนกันยายน พ.ศ. 2546 และเปรียบเทียบแบบจับคู่กับผู้ป่วยที่ได้รับการผ่าตัดด้วยวิธีปกติ (standard TKA) ในช่วงเวลาเดียวกัน ผู้ป่วยทุกรายได้รับการติดตามอย่างน้อย 12 สัปดาห์หลังจากการผ่าตัด การเปรียบเทียบข้อมูลในการผ่าตัด และผลของการผ่าตัดระหว่างกลุ่ม mini-incision TKA และ standard TKA มีดังนี้ ค่าเฉลี่ยเวลาผ่าตัด 137.1 และ 115.8 นาที ( $p=0.02$ ) ค่าเฉลี่ยความยาวของขนาดแผล 9.4 และ 13.7 เซนติเมตร ค่าเฉลี่ยการเสียเลือด 456 และ 512 มิลลิลิตร ( $p=0.14$ ) จำนวนผู้ป่วยที่สามารถเดินได้ในวันรุ่งขึ้น 17 และ 2 คน ร้อยละของผู้ป่วยที่สามารถเหยียดข้อเข่าด้วยแรงตนเองในวันรุ่งขึ้นหลังการผ่าตัดเท่ากับ 82 และ 0 ตามลำดับ ที่ 24 ชั่วโมง, 48 ชั่วโมงหลังการผ่าตัด คะแนนของความเจ็บปวดของทั้ง 2 กลุ่มไม่มีความแตกต่าง แต่ที่ 2 และ 6 สัปดาห์ กลุ่ม mini-incision TKA มีคะแนนน้อยกว่าอย่างมีนัยสำคัญ ( $p=0.002$  และ  $p=0.002$ ) มุมการเหยียดและงอของข้อเข่ากลุ่ม mini-incision TKA มากกว่ากลุ่ม standard อย่างมีนัยสำคัญที่ 2 สัปดาห์อย่างไรก็ตาม ที่เวลา 12 สัปดาห์ ไม่มีความแตกต่างของความเจ็บปวดและมุมการงอข้อเข่าในผู้ป่วยทั้ง 2 กลุ่ม การผ่าตัดเปลี่ยนข้อเข่าเทียมด้วยวิธีเนื้อเยื่อบาดเจ็บน้อยทำให้ผู้ป่วยฟื้นตัว เดินได้เร็วขึ้น และความสามารถงอข้อเข่าหลังผ่าตัดเร็วขึ้น