Case Report

Multidirectional Kirschner Wires and Wiring Fixation for Displaced Comminuted Patellar Fracture: Cases Report

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Background: The modified anterior tension band [MATB] wiring proposed by the Arbeitsgemeinschaft für Osteosynthesefragen [AO] has become the most prevalent technique for patellar fractures treatment in recent years. However, this technique is associated with a well-known difficulty when applied to the fixation of comminuted patellar fractures that is due primarily to the unidirectional nature of conventional K-wires installation and the higher number of fractured bones involved.

Objective: To propose a novel fixation technique for displaced comminuted patellar fractures using multidirectional K-wires and wiring.

Case Report: In the present prospective study, the authors enrolled six patients (average age of 41.7 years) with displaced comminuted patellar fractures. All the patients were treated with an open reduction and internal fixation [ORIF] procedure using multidirectional K-wires and wiring. The Lyshölm knee score (at 6 weeks, 12 weeks, 6 months and 12 months), the range of motion of the knee (at 12 weeks and 12 months), and the time required for radiographic bone union were recorded postoperatively. Any signs of other complications were also noted.

Results: The mean Lyshölm knee scores were 80.8±4.6, 86.5±3.1, 93.0±2.1 and 96.8±2.6, at 6 weeks, 12 weeks, 6 months and 12 months, respectively. The range of motion at 12 weeks and 12 months were 120.8±6.4 and 135.5±3.3 degrees. In all cases, the mean duration of healing time was 11 weeks. Neither breakage nor migration of installed wires was observed. Nevertheless, some hardware irritations, which limited the range of motion in extreme flexion, were reported by three patients.

Conclusion: The proposed fixation technique was based on the use of simple multidirectional K-wires and wiring. This method served as a direct extension of the AO's MATB technique. The preliminary successful clinical results suggest its applicability in dealing with the troublesome treatment of displaced comminuted patellar fracture.

Keywords: Patellar fracture, Displaced fracture, Comminuted fracture, Fixation technique

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The incidence of patellar fractures accounts for 1% of all musculoskeletal system fractures, and one third of those patients require a surgical intervention[1,2]. The operative indications include fractures with more than 2 mm of articular displacement, 3 mm of fragment separation, comminuted fractures with displacement of the articular surface, osteochondral fractures with displacement into the joint, and marginal or longitudinal fractures with comminution or displacement. Because the patellar bone is a subcutaneous bone that is a part of a patellofemoral joint, the need for early postoperative knee motion is critical to reduce joint stiffness. An appropriate fixation technique for a patellar fracture, especially in a displaced and comminuted fracture, is still a challenge for orthopedic surgeons to reach a satisfactory outcome and minimize complications such as the frequency of re-operation, infection, and non-union[3].

Currently, a standard surgical intervention for a transverse fracture of the patella is the Arbeitsgemeinschaft für Osteosynthesefragen [AO] modified anterior tension band [MATB] with vertical figure-of-eight wire[4]. However, for a displaced and comminuted (at least three fragments of the bone and each fragment is 4 mm in size or more)[5] patellar fractures, there are many different techniques reported in the literature. Some techniques[6-17] require the specific equipment, some techniques have trouble with a small fragment fixation, and some techniques could not provide adequate immediate stability of the patella, resulting in limitation of early active knee motion.

The authors provided a fixation in these cases by using multidirectional Kirschner wires [K-wires] and

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wiring. The purpose of our study was to evaluate the effectiveness of the present technique in the treatment of displaced comminuted patellar fracture.

Case Report

Patients

The present prospective study was conducted in a 500-bed teaching hospital between March 2013 and April 2014. The inclusion criteria of our patients were the general physical condition of the patients, could withstand the anesthesia and operation, fractures with at least three fragments (4 mm in a diameter or more) and with an articular displacement (step-off) of more than 2 mm or a separation of the fragments more than 3 mm, fractures that disrupted the quadriceps mechanism, and no local or remote active infection. The exclusion criteria were age younger than 15 years old, associated other periarticular fracture of the same knee (e.g., tibial plateau, femoral condyle), previous knee surgery, the patients with cerebrovascular disease, neuromuscular disease, or endocrine abnormalities, and absolute alcohol consumption (more than 60 gm per day in male and more than 20 gm in female) or chronic smoking (more than 20 pack per year).

Four male and two female patients with displaced and comminuted patellar fracture were enrolled in the present study. The patients' ages ranged from 17 to 59 years (average age of 41.7 years).

The consent forms from the patients and approval from the Ethics Committee of our institution were obtained. All patients underwent the open reduction and internal fixation [ORIF] with multidirectional K-wires and wiring by the same senior orthopedic surgeon (Sastravaha N). After the operation, the patients were followed up to evaluate the function of the knee using the Lyshölm score, the range of motion of the knee at 12 weeks and 12 months, the time required for radiographic bony union, defined as bone bridging across the fracture site in three of four cortical rims observed from Knee AP and lateral views, and the presence of any postoperative complications.

Surgical technique

First, an intravenous antibiotic (cefazolin 1 gm, or clindamycin 900 mg in penicillin-allergic patient) was administered to the patient 30-minute before the operation. Under appropriated anesthesia and tourniquet application, an anterior midline longitudinal incision approximately 7 cm in length was made above the patella. After blood clot removal, the authors carefully collected all the cartilage-containing bony fragments and the cortical pieces that might affect the stability of the patella. The articular surface was gradually restored to the nearest of their anatomical position by its configuration. The authors applied point reduction clamps to temporary maintain their position and checked an articular congruity by manual finger palpation. The 1.6 mm to 1.8 mm K-wires were inserted in a one-by-one manner and their directions were determined by the individual fracture configuration of each patients and the symmetric coverage to the patellar bone (Figure 1A). Then, the 1.2 mm wires were used to wire the end of the K-wires in group, contained at least 2 K-wires, in a figure-of-eight manner until no K-wire were left unwired (Figure 1B-D). The last 1.2 mm wire was used to perform a cerclage wiring under all the end of K-wires. Bending the end of each K-wire and cut it respectively (Figure 1E, F). At this point, the knee was gently flexed to ensure the stability of the fixation. Lastly, a radivac drain was applied and any incisions or tears observed in the retinacula were repaired. The authors assessed the range of knee motion again to ensure that there was no restriction in knee motion before closing the wound. The authors applied a Jones bandage around the knee in full extension position.

Postoperative rehabilitation

The affected limb was raised in the first post-

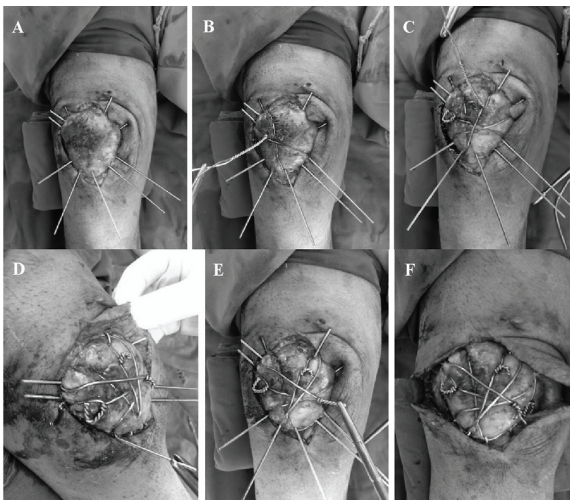

Figure 1. A) Displaced comminuted patellar fracture after reduction and fixation with the 1.6 to 1.8 mm K-wires. B) First 1.2 mm figure-of-eight wiring was applied with three ending K-wires included. C, D) Repeated wiring in figure-of-eight manner until no K-wire left unwired. E) Bending the end of each K-wire and cut them. F) Displaced comminuted patellar fracture after open reduction and internal fixation with multidirectional K-wires and wiring.

operative day. Passive knee motion exercises began on the second day postoperatively by using the continuous passive motion [CPM] device, and limiting knee flexion at 90 degrees after the removal of the Redivac drain. An active range of motion could be initiated consecutively as tolerated by the patient. After three to five days, the authors focused on an isometric exercise of the quadriceps along with gradually increasing the arc of motion of the knee. At this point, the patient could ambulate by themselves, partial-weight bearing with an axillary crutch for two weeks under the supervision of the physiotherapists. Full-weight bearing was allowed after a 4-week period, but any vigorous activities should be avoided until a radiographic union was achieved. The authors advised all patients to undergo the operation for removing the instrument after healing of the fracture if it caused symptoms or six to twelve months if it did not cause symptoms. If a problem of implant breakage occurred, the authors could remove it at the bended ending of the K-wire without retaining instrument.

Statistical analysis

The authors reported our outcomes by using mean value and its standard deviation. Microsoft excel version 15.21.1 was used to analyze the data. Our graphic charts were created by using Pages version 6.3.

Results

All the patients were followed for an average of 13 months (range 8 to 20 months) and the demographic data of all patients are shown in Table 1.

Functional knee score (Lyshölm knee score)

For our primary outcome, the mean Lyshölm knee scores at 6 weeks, 12 weeks, 6 months, and 12 months after surgery were 80.8±4.6, 86.5±3.1, 93.0±2.1, and 96.5±2.6, respectively. All patients could return to nearly their preoperative activity level.

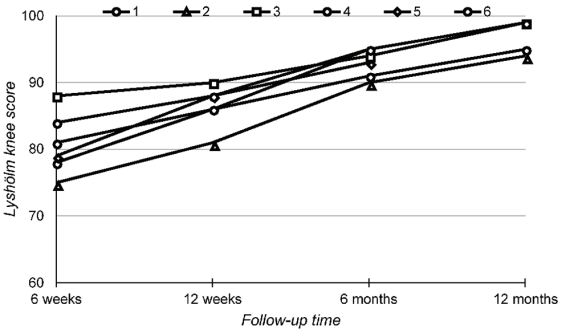

Figure 2. Showed Lyshölm knee score of each patient at 6 weeks, 12 weeks, 6 months, and 12 months postoperatively.

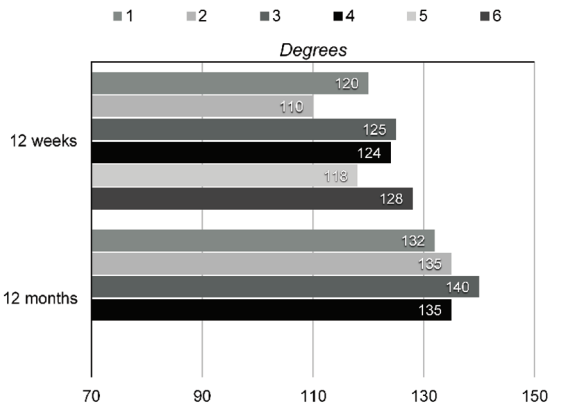

Figure 3. Showed the range of motion of each patient at 12 weeks and 12 months postoperatively.

Range of motion

At 12-week postoperative, the mean range of motion measured by goniometer of an affected knee joint was 0 to 120.8±6.4 degrees (range 110 to 128 degrees). The mean range of motion of the affected knee was 0 to 135.5±3.3 degrees (range 132 to 140 degrees) at 12-month postoperatively.

Time of radiographic bone union

The mean duration between the operation and the

Table 1. Demographic data of the 6 patients

No.	Age (year)	Sex	Smoking	Alcohol assumption	Type of fracture (open/closed)	No. of fragments	No. of K-wires	Operative time (minute)	Follow-up (month)
1	41	M	Yes	Yes	Closed	4	4	45	20
2	55	F	No	No	Closed	5	4	48	18
3	37	M	No	Yes	Closed	4	4	60	14
4	41	M	No	No	Closed	4	4	50	12
5	59	F	No	No	Closed	5	4	45	8
6	17	M	No	Yes	Closed	4	4	55	8

M = male; F = female

Table 2. Outcomes of operated patients: Lyshölm knee score, range of motion, time to unions, and complications

No.	Lyshölm knee score (6 weeks/12 weeks/6 months/12 months)	Range of motion (extension/flexion) (12 weeks/12 months)	Time to union (weeks)	Complications
1	81/86/91/95	0/120 0/132	12	None
2	75/81/90/94	0/110 0/135	10	Irritation hardware
3	88/90/94/99	0/125 0/140	11	Irritation hardware
4	78/86/95/99	0/124 0/135	12	Irritation hardware
5	79/88/93/-	0/118	11	None
6	84/88/95/-	0/128	12	None

radiographic union in our studies was 11.3±1.0 weeks.

Complications

Three patients complained about the hardware irritation during the follow-up period, but only at an extreme flexion of the knee especially in squatting position. No other postoperative complications, such as delayed wound healing, wound infection, migration, or breakage of the implants were observed through the final follow-up examination.

Discussion

The MATB wiring proposed by the AO has become the most prevalent technique for patellar fractures treatment in recent years[4]. However, this technique is associated with a well-known difficulty when applied to the fixation of comminuted patellar fractures, which is due primarily to the unidirectional nature of conventional K-wires installation and a higher number of fractured bones involved. The fixation technique, using multidirectional K-wires and wiring might play a role in this situation.

At the outset of the present study, the main benefits of our techniques were in case of severe comminuted fragments and small-to-fix fragments by other instruments. Thus, the K-wires remain the choice of fixation in this situation that provide an immediate stability. As a result, the authors could start functional exercise with CPM and active quadriceps exercises at the second postoperative day in our cases, and no loss of the fixation or displacement of the fragments was found. This might be one of the reasons that satisfactory results were noted at the end of our study. On the other hands, the authors concerned that the multidirectional K-wires and wiring would cause soft tissue irritation and anterior knee pain. Although, this phenomenon was seen in three of six patients, their activities were just limited to the positions with extreme knee flexion such as fully squatting, but not limited to their normal activities of daily living and the average range of motion, which at 12 weeks and 12 months were 120.8±6.4 and 135.5±3.3 degrees.

As of now, there is no specific scoring system for evaluating the patellar fracture. Therefore, the scoring system developed by Lyshölm is used widely to address patellar fracture fixation[9,10,17].

From our study, the average Lyshölm score reach fair outcome (65 to 83) at six weeks postoperatively by mean of 80.8±4.6, and improve to good outcome (84 to 90) at 12 weeks by mean of 86.5±3.1. At 6 and 12 months of follow-up, the score could reach excellent outcome (greater than 90) by mean of 93.0±2.1 and 96.8±2.6, respectively. Comparable results were observed in a few studies. Yanmis et al[17], using a circular external fixator [CEF] under arthroscopic control in four patients (three of them were comminuted), showed the mean Lyshölm knee score of comminuted group at 12 months was 93.3±7.6 and bone union was seen at 6.7±1.2 weeks. The union time from that study seemed to be shorter than ours because of closed reduction manner used. Yotsumoto et al[9], used tension band fixation with braided polyblend sutures and specific ring pins, also showed an excellent result by Lyshölm knee score in 13 patients (six of them were comminuted). At 12 months, the mean score of comminuted group was 94.7±5.2 and the mean range of motion was 133.3±8.2 degrees. Bone union was seen at 3.2±0.3 months. Other technique proposed by Qi et al[10] included bioabsorbable cannulated lag screws and braided polyester suture tension bands were used in 15 patients and three of them were comminuted. At 12 months, the mean score of comminuted group was 92.0±2.6 and the mean range of motion was 126.7±5.8 degrees. Bone union was seen at three months.

Without specific instrument needed, the technique, using multidirectional K-wire and wiring, showed an

excellent outcome by Lyshölm knee score in all patients with displaced comminuted patellar fracture. An early rehabilitation with full-motion of the knee was allowed as soon as pain subsided. However, Three patients complained about the hardware irritation during the follow-up period at an extreme flexion of the knee without the need of hardware removal.

Limitations of our study are 1) single center study, 2) the lack of a control group in the clinical arm, 3) the assessor are not blinded, and 4) the results could be applied only in isolated comminuted displaced patellar fracture (no associated injuries, e.g., collateral ligament, cruciate ligament, etc.).

More high-quality, double-blinded randomized controlled trials with more case numbers are needed to confirm the advantages of our technique and that the high-tensile-strength non-absorbable suture (e.g., braided polyester) could be used in this fashion to avoid metal-related complications.

Conclusion

This fixation technique was proposed based on the use of simple multidirectional K-wires and wiring. This method serves as a simple direct extension of the AO's MATB technique without any additional resources. The preliminary successful clinical results suggested its applicability in dealing with the troublesome treatment of displaced comminuted patellar fracture.

What is already known on this topic?

Nowadays, there are many options to deal with displaced comminuted patellar fracture. First, many orthopedists use tension band wiring principle with various techniques of fixations and materials, such as usage of ring pin or bioabsorbable screw to fix the fragments before applying a figure-of-eight wire, or usage of polyester suture or titanium cable instead of stainless steels. Second, some use specifically designed equipment to solve this situation such as basket plate or patellar ring. Last, an arthroscopically assisted semi-circular ring external fixator with K-wires was also used in a small case series. One of the benefits of this technique is a small incision, but six to eight weeks of wearing external fixation can be a major drawback.

Even though, there are many methods to solve the displaced comminuted patellar fracture, all of them require specific instrument that may not be available in most regional hospitals in Thailand.

What this study adds?

The authors would like to show the preliminary result of our fixation technique using multidirectional K-wires and wiring in displaced comminuted patellar fracture. At the end of the process, the knee functional outcomes showed excellent result with only minor complications such as skin irritation. More high-quality, double-blinded randomized controlled trials with greater case numbers are needed to confirm the advantages of our technique and the high-tensile-strength non-absorbable suture (e.g., braided polyester) could be use instead in this fashion to avoid metal-related complications.

Potential conflicts of interest

The authors declare no conflict of interest.

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