Comparison of the Cable Pin System With Conventional Open Surgery for Transverse Patella Fractures

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Abstract

Background The cable pin system is an effective device for fixation of transverse patella fractures. However, whether this device provides superior results using a minimally invasive technique instead of conventional open surgery using the K wire tension band method is unclear. **Questions/purposes** We asked whether a minimally invasive technique would be associated with (1) increased operative time; (2) reduced postoperative pain; (3) faster recovery of ROM; (4) higher knee scores; and (5) reduced complications. **Methods** Forty patients with displaced transverse fractures of the patella participated in this prospective, randomized,

controlled trial. Twenty of these patients underwent a minimally invasive technique and the others had conventional open surgery using K wires. Some data for six of the 20 patients who underwent the minimally invasive technique were published in an earlier prospective, observational trial. At postoperative intervals of 1, 3, 6, 12, and 24 months, pain was measured by VAS scores, active flexion and extension of the knee were measured in degrees by goniometry, and knee function was evaluated using the Böstman clinical grading scale.

Results Operative time was longer in the minimally invasive surgery group (54.3 ± 9.8 minutes versus 48.5 ± 6.1 minutes). Pain scores were better (lower) in the minimally invasive surgery group at 1 and 3 months but not at 6 months. Early flexion, ultimate flexion, and knee scores from 3 to 24 months, likewise, were better in the minimally invasive surgery group. Complications mostly related to symptomatic hardware were less common in the minimally invasive surgery group.

Conclusions The minimally invasive technique is superior to conventional open surgery using K wires in terms of less early postoperative pain, better mobility angles of the injured knee, higher functional score of the injured knee, and decreased incidence of complications.

Level of Evidence Level I, therapeutic study. See the Guidelines for Authors for a complete description of levels of evidence.

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Introduction

Patellar fractures account for approximately 0.5% to 1.5% of all bone fractures [12]. A transverse fracture is the most common type of patella fracture, which often causes functional disability of the knee extensor apparatus with displacement of the fractured fragments [3]. Surgical treatment is recommended when fragment displacement is 2 to 3 mm or when there is joint incongruity [7].

Currently, the usual surgical intervention for treatment of transverse patella fractures is open reduction with a sufficient incision and internal fixation using a K wire with the modified tension band method [5, 6, 18]. However, this approach is associated with delayed wound healing, post-operative adhesions, knee stiffness, and prolonged work disability [1, 19]. Additionally, symptoms and complications related to use of K wires are common, including wire breakage and migration, with subsequent painful and prominent hardware in the knee, occasional loss of reduction, migration of fracture fragments, and soft tissue irritation [13, 14, 18, 21, 24].

Some authors have suggested combining lag screw and tension band principles provides enhanced fixation strength compared with the modified tension band construct [4, 8, 10]. The cable pin system (Cable-Ready®; Zimmer®, Inc, Warsaw, IN, USA) is a combination of the interfragmentary screws (paralleled pins) and the tension band wire (a figure-eight cable) [17]. In the current article, we present results of a small randomized, controlled trial using a minimally invasive technique using the cable pin system for transverse patella fractures. The goals of this study were to compare the minimally invasive technique with conventional open surgery using the K wire tension band method. We hypothesized that the minimally invasive technique with the cable pin system would be associated with (1) increased operative time; (2) reduced postoperative pain; (3) faster recovery of ROM; (4) higher knee scores; and (5) reduced complications.

Patients and Methods

Forty patients (25 males and 15 females) with clinical and radiographic evidence of a transverse patella fracture with greater than 3 mm displacement participated in and completed this randomized, controlled study at our hospital from April 2008 to June 2010 (Fig. 1). The age of the patients at the time of surgery was 33 years (range, 22–65 years). The study inclusion criteria were age between 18 and 65 years, a clinical course less than 48 hours, and the patient's willingness to participate in the study after providing informed consent. The exclusion criteria included open fracture, comminuted or multiple fractures, multiple trauma, fracture associated with preexisting osteoarthritis of the knee, previous surgical intervention of the knee, peripheral neural damage, uncompensated diabetes, and serious osteoporosis. Participants were randomly assigned following simple randomization procedures (computerized random numbers) to one of two treatment groups. The allocation sequence was concealed from the researcher enrolling and assessing participants in sequentially numbered, opaque, and sealed envelopes. Corresponding envelopes

Fig. 1 A preoperative lateral radiograph shows the displaced transverse fracture of the patella. The fracture line is near distal of the patella.

were opened only after the enrolled participants completed all baseline assessments and it was time to allocate the intervention. Twenty patients were randomly assigned to receive the minimally invasive cable pin system technique and 20 were scheduled by means of a sealed-envelope procedure for conventional open surgery with the K wire tension band method. The first six patients who were randomized to the minimally invasive cable pin system group also were included in a previously published observational study in which this technique was described [17]. Both studies were approved by the ethics review committee of the Second Military Medical University and written informed consent was obtained from all patients. All operations were conducted by two of the authors (QZ, NM) using the same surgical protocol. Data were collected and analyzed by three of the authors (DL, HN, HT) and another orthopaedic surgeon from our institution (YX).

The cable pin system is a new type of internal fixation system which aims to combine the concepts of use of a cable and a pin. One end of the system is a partially threaded 4.0-mm cancellous screw (pin) (length, 35–60 mm). The thread of the pin can provide compression between fragments and prevent the cancellous screw from backing out. The other end of the system is a guide needle, which can be passed easily through bone tunnels. The material connecting the two ends is a cable with a special braiding structure. It is braided from 19 wires with each wire containing seven monofilament wires with a diameter of 0.005 mm. Therefore, a cable comprises 133 monofilament wires. This design provides the cable with great strength and excellent pliability.

The minimally invasive cable pin technique was described in detail in an earlier study [17]. The standard open surgery K wire tension band technique was performed using the previously described procedure for open reduction and fixation [23].

For all patients in both groups, an elastic bandage was used for 2 days after surgery to reduce swelling and hematoma of the knee. No immobilization was used. Passive exercise was initiated on Day 1 after surgery. Patients used a continuous passive motion machine, and active flexion exercises of the knee in a prone position were encouraged. The patients began getting out of bed on postoperative Day 3 and were encouraged to start bearing weight during level walking. Active extension exercises of the knee were allowed 3 weeks after surgery, and full weightbearing was allowed after the fracture was radiographically healed.

All patients were followed in a similar fashion. Generally, patients were assessed every 2 weeks in the first month, then once monthly until 6 months, and once every 6 months thereafter. The clinical and radiographic evaluations were performed by two orthopaedic surgeons (HT, YX), neither of whom had participated in the surgical procedures. The evaluation was not blinded because the surgical incision and fixation device allowed the assessors to identify the group to which the patients belonged.

Evaluation of the wound and suture removal were conducted on the tenth postoperative day. At routine postoperative intervals of 1, 3, 6, 12, and 24 months, pain was measured by the VAS using scores from 0 (no pain) to 10 (the most intense pain), and active flexion and extension of the knee were measured in degrees by goniometry. Knee function was evaluated using the clinical grading scale described by Böstman et al. [2] as follows: total score less than 20 = unsatisfactory; 20 to 27 = good; and 28 to 30 = excellent.

The Mann-Whitney U test was used to compare quantitative variables and the chi-square test with continuity correction or Fisher's exact test was used to compare frequency distributions of nonquantitative variables between the two groups. These nonparametric statistical tests were chosen because our variables were nonnormally distributed. All statistical analyses were done using SPSS 15.0 statistical software (SPSS Inc, Chicago, IL, USA), and a p value less than 0.05 was considered to indicate statistical significance.

The study populations were similar at baseline in terms of patient factors, injury-related traits, and time to surgery (Table 1). Because some of the patients undergoing the minimally invasive cable pin technique were enrolled in an earlier prospective, observational study [17], we are presenting per-patient demographic and injury data to facilitate future meta-analyses on this population and avoid the chance that patient data will be counted twice (Appendix 1. Supplemental materials are available with the online version of CORR.).

Table 1. Demographics of two groups

Demographic	MICP group (n = 20)	OSKW group (n = 20)	p value
Sex			
Male	14 (35%)	11 (27.5%)	0.514*
Female	6 (15%)	9 (22.5%)	
Age (years)	40.2 ± 10.0	43.5 ± 11.4	0.329 [†]
Side			
Left	12 (30%)	9 (22.5%)	0.527*
Right	8 (20%)	11 (27.5%)	
Mechanism of injury			
Fall	13 (32.5%)	16 (40%)	0.564 [‡]
Traffic accident	5 (12.5%)	3 (7.5%)	
Sports-related trauma	2 (5%)	1 (2.5%)	
Time between injury and operation (hours)	30.8 ± 9.8	33.9 ± 7.4	0.265 [†]
Frequency of intraoperative fluoroscopy	3.25 ± 0.6	1.7 ± 0.7	< 0.001 [†]
Operating time (minutes)	54.3 ± 9.8	48.5 ± 6.1	0.031 [†]

All values are mean ± SD or number of patients; * chi-square test with continuity correction; [†]Mann-Whitney U test; [‡]Fisher's exact test (fall versus all others); MICP = minimally invasive technique; OSKW = conventional open surgery using the K wire tension band method.

Our plan was to follow up all patients at least 2 years. In reality, one patient from the open surgery K wire tension band group sustained a broken tibia as a result of a traffic accident 16 months after surgery; thus, there were only 39 patients for evaluation at the 24-month followup.

Results

Operative time for the minimally invasive surgery group was longer than that of the open surgery K wire tension band group (54.3 ± 9.8 minutes versus 48.5 ± 6.1 minutes; p = 0.031). Likewise, intraoperative fluoroscopy was used more frequently in the minimally invasive surgery group than in the open surgery K wire tension band group during the procedure (p < 0.001). Again, because some of the patients undergoing minimally invasive surgery were enrolled in our earlier prospective, observational study [17], we are presenting per-patient data for all result parameters separately (Appendix 2. Supplemental materials are available with the online version of CORR.).

Pain scores were higher (worse) in the open surgery K wire tension band group than in the minimally invasive group during active movement of the injured knee at 1 and 3 months after surgery; by 6 months, no significant differences were observed (Table 2).

Compared with the open surgery K wire tension band group, the minimally invasive surgery group had gained more ROM in extension at 1 month after surgery, but this difference was not significant by 3 months after surgery. ROM in flexion was significantly better in the minimally invasive surgery group at all followups (Table 2).

The average Böstman scores were greater in the minimally invasive surgery group at 3, 6, 12, and 24 months (Table 2).

During the followup period, four patients from the minimally invasive surgery group and 15 from the open surgery K wire tension band group had their hardware removed between 12 and 15 months after surgery owing to

pain, irritation, or psychologic reasons (Table 2). The overall frequency of complications was 5% in the minimally invasive surgery group and 32.5% in the open surgery K wire tension band group ($p < 0.001$).

Discussion

Minimally invasive surgery is the current trend for treatment of patella fractures. This less painful technique theoretically can protect the blood supply of the fragments and the biologic environment at the fracture site and facilitate immediate postoperative mobilization and earlier rehabilitation, which consequently prevents posttraumatic arthritis, joint adhesions, ankylosis, and muscular atrophy, resulting in better knee mobility, higher functional score, and lower incidence of complications compared with open surgery [11, 13, 16, 20, 25]. However, the minimally invasive technique has not been specifically evaluated, and in this study, we sought to compare it with the more traditional open surgery K wire tension band approach in terms of operative time, postoperative pain, recovery of ROM, knee scores, and complications.

This study has some limitations. This was a single-center, open-label trial, and the sample size was relatively small. The two surgical methods and hardware are so different that it is impossible to design a blinded study; thus, the current study design might be a cause of bias. Randomization may have offset this somewhat by minimizing the likelihood of selection bias. Four patients in the minimally invasive surgery group and 15 in the open surgery K wire tension band group underwent a second surgery between 12 and 15 months after surgery for removal of their hardware, which might have influenced knee function assessment at 24 months; this is fairly common in the treatment of patella fractures. The early, statistically significant differences between the groups were modest in size (1 to 2 cm on a 10-cm scale), however, and whether these are clinically important is unknown. Another limitation of the minimally invasive surgery technique was that most of the fractures were indirectly reduced without adequate observation of the fracture. The minimally invasive technique is warranted only for simple, noncomminuted transverse fractures that can be adequately reduced by indirect means. Finally, six patients in the minimally invasive surgery group also were followed as part of an earlier prospective, observational study.

There are some studies describing other percutaneous fixation methods for treatment of patellar fracture with the assistance of fluoroscopy [1, 16, 17, 20, 22, 25]. Reduction by indirect means is not difficult during surgery, but the time spent is more than with open reduction methods. We believe this was the cause of the increased need for fluoroscopy and

Table 2. Comparison of postoperative results in MICP and OSKW patient groups

Result	MICP group (N = 20)	OSKW group (N = 20)	p value
VAS score for pain			
1 month	3.6 ± 1.2	5.6 ± 1.3	< 0.001*
3 months	1.2 ± 1.1	2.6 ± 1.2	0.001*
6 months	0.2 ± 0.4	0.5 ± 0.7	0.170*
Flexion (°)			
1 month	35.5 ± 11.6	19.8 ± 10.7	< 0.001*
3 months	79.8 ± 18.5	59.3 ± 11.8	< 0.001*
6 months	111.3 ± 19.6	97.5 ± 16.2	0.020*
12 months	121.5 ± 10.9	113.5 ± 11.3	0.028*
24 months	123.3 ± 8.9	115.0 ± 12.8	0.025* [‡]
Extension (°)			
1 month	−3.3 ± 1.8	−5.3 ± 2.3	0.006*
3 months	−0.9 ± 1.2	−1.8 ± 2.2	0.112*
Bostman score			
3 months	25.8 ± 1.5	23.4 ± 2.8	< 0.001*
6 months	28.1 ± 1.5	26.6 ± 2.2	0.009*
12 months	28.8 ± 1.2	27.8 ± 1.9	0.036*
24 months	28.9 ± 1.0	27.9 ± 1.9	0.041* [‡]
Complications			
Total number of patients with complications	2 (5%)	13 (32.5%)	< 0.001 [†]
Delayed wound healing	0	2 (5%)	
Loss of reduction	0	2 (5%)	
Migration hardware	0	5 (12.5%)	
Irritation hardware	2 (5%)	8 (20%)	
Broken wires	0	2 (5%)	
Remove of hardware	4 (10%)	15 (37.5%)	< 0.001 [†]

All values are mean ± SD; * Mann-Whitney U test; [†]chi-square test with continuity correction (complicated versus noncomplicated); [‡]39 patients (one patient in OSKW group had a broken tibia following a traffic accident) were evaluated; MICP = minimally invasive technique; OSKW = conventional open surgery using the K wire tension band method.

Fig. 2A–C (A) The postoperative incision is shown. (B) Postoperative AP and (C) lateral radiographs show the anatomic reduction of the patella fracture.

longer operative times in the minimally invasive surgery group.

Immediate mobilization and early weightbearing were encouraged after surgery and lower VAS scores for pain were observed at 1 and 3 months after surgery, which could be partially attributed to less destruction of the soft tissues (Fig. 2). Luna-Pizarro et al. [16] compared a new percutaneous technique with conventional open surgery for displaced patellar fractures. They also found that postoperative pain at 4 and 8 weeks was significantly greater in the open surgery group than in the percutaneous technique group.

ROM and Böstman functional scores were greater in the minimally invasive group at almost all followups, suggesting better early rehabilitation in patients who underwent the minimally invasive technique. This may have been a function of the longer incision and more extensive soft tissue dissection in the open surgery K wire tension band group, and subsequent joint adhesions, which could have had an impact on restoration of knee function. Luna-Pizarro et al. [16] and Chiang et al. [9] also assessed knee functional recovery postoperatively with other knee function scoring systems; the results showed better scores in patients with patella fractures who received the minimally invasive technique rather than open surgery.

The pliability of the cable pin system made it possible for the cable to contact the bone surface more tightly without breaking, providing more reliable stability and decreasing the known complications with stainless steel wire. In a large series of patella fractures, the incidence of complications related to stainless steel wire loops was 47%; furthermore, 15% of patients had associated symptoms and required wire removal [15]. In our study, two

patients from the minimally invasive surgery group had complications resulting from hardware irritation, whereas 13 from the open surgery K wire tension band group had complications, including delayed wound healing, loss of reduction, migration and irritation of hardware, and broken wires. As a result of these complications and the traditional concepts of some Chinese populations (two patients from the minimally invasive group and three from the open surgery group) who usually are unwilling to live with hardware in their body forever, four patients of the minimally invasive group and 15 in the open surgery group underwent a second surgery for hardware removal. There is no doubt that two operations would result in substantially more pain, work disability time, and economic burden than a single operation.

In our small randomized study, we found increased operative time and need for fluoroscopy, but less early postoperative pain, better ROM, higher functional scores of the injured knee, and fewer complications in the minimally invasive surgery group compared with patients in the open surgery K wire tension band group. These results should be confirmed in a larger multicenter trial.

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