Transosseous suturing of patellar fractures with braided polyester – A prospective cohort with a matched historical control study

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A R T I C L E   I N F O

Article history:
Accepted 21 June 2013

Keywords:
Transosseous suturing
Patellar fracture
Tension-band wiring

A B S T R A C T

Background: Although tension-band wiring is the most widely used technique to fix patellar fractures, metal implant-related complications including implant failure and postoperative pain are very common and additional procedures are often necessary to treat the complications. The purpose of this study is to evaluate a totally metal-free technique using a transosseous suturing method and to compare it with the traditional fixation technique.

Method: A total of 25 patients (mean age of 59.60 years) with displaced patellar fractures treated by a transosseous suturing technique were compared with a 1:1 matched historical control group that underwent modified tension-band-wire fixation. Union time, union rate, operation time, number of procedures, mean hospitalisation days and complications were compared between cases and controls.

Results: Union time (8.43 ± 2.92 vs. 8.64 ± 2.82 weeks) and operation time (69.00 ± 19.31 vs. 64.89 ± 14.27 min) were not different between the two groups. Mean hospitalisation days (4.04 ± 1.40 vs. 5.76 ± 1.50 days; P < 0.001), number of procedures and the frequency of complications were significantly lower in the transosseous suturing group.

Conclusion: The transosseous suturing technique is safe and effective in the transverse or comminuted fractures of the patella. The complication rate is significantly lower than with the tension-band-wiring technique.

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The incidence of patellar fractures accounts for 1% of all musculoskeletal system fractures [16]. Indications for surgical intervention include fractures with >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 [10]. The most popular operation method to fix the patellar fracture is the Arbeitsgemeinschaft für Osteosynthesefragen (AO)-modified tension-band-wiring technique [2,22,23]. However, the implant-related complication rate varies from 32.8% to 47% [12,14]. To reduce the metal-implant-related complications, several modified tension-band-wiring techniques have been studied [15,25]. Regardless of modification, metal implants seem to be palpable under the skin and implant removal is inevitable in symptomatic patients. Instead of using metal implants, some authors used non-absorbable sutures to fix the fracture with various techniques [6,10,11,20]. Each study showed that non-absorbable sutures have a comparable union rate but less complication and implant removal rate than a conventional fixation technique. Transosseous wire fixation of the patella has been reported by Lotke et al. [16] Their technique involves longitudinal drill holes through which a metal wire is pulled and looped over the anterior surface of the patella. It allows excellent inter-fragmentary compression, provides an anterior tension band and prevents a retropatellar step-off [16]. Tension-band fixation employing two parallel Kirschner’s wires and a braided polyester tightened by the modified Wagoner’s Hitch showed less fracture gap than other recognised tension-band suture and wire techniques in an in vitro biomechanical test [11]. However, to the best of our knowledge, there is no clinical series reporting a combination of Lotke’s technique and a braided polyester tightened by the modified Wagoner’s Hitch in the English literature.

Patients and methods

This prospective study was conducted in a 2500-bed teaching hospital from August 2010 to February 2011. We employed a
matched control group (1:1 matching) of patients identified from the historical database of our institute.

**Prospective cohort**

A total of 32 patients with patellar fracture were admitted to our institute from September 2010 to February 2011. With the approval of our hospital’s institutional review board, 25 patients were enrolled in our study. The inclusion criteria were age >18 years, displaced >3 mm and subject’s agreement with informed consent to participate in the study after providing adequate information. Seven patients were not included in this study due to the following reasons: two patients had trauma of multiple systems and delayed surgery due to unstable conditions, two patients presented with open fracture, one presented with congenital musculoskeletal disorder, one patient presented with active infection or inflammation around the knee and one patient did not wish to participate in the study. The following exclusion criteria were adopted: multiple trauma, open fracture, congenital musculoskeletal disorder, active infection or inflammation around knee.

**Matched historical control group**

The historical cohort population was selected from patients who underwent surgery for patellar fracture in our institute from January 2000 to August 2010. There were 483 patients receiving open reduction and internal fixation with AO-modified tension-band-wiring technique for patellar fracture. A cohort of 25 patients matched 1:1 with the study group for age (±5 years) and gender were selected with the same inclusion and exclusion criteria as the study group. For example, if we had a 30-year-old man in study group, then we randomly selected a male patient with age ranging from 25 to 35 years from the historical cohort as the corresponding control.

**Surgical technique and follow-up**

All of the patients in the transosseous suturing technique group underwent a standardised operation procedure by a senior fellow of orthopaedic traumatology in our institute. After spinal anaesthesia, the patient was placed in a supine position with a pneumatic tourniquet inflated to 300 mm Hg. A longitudinal midline skin incision was made. An intra-articular haematoma from the knee joint was drained and the blood clot and soft tissue from the fracture site were removed. Fracture fragments were anatomically reduced by directly palpating the congruency of the articular surface through a lateral arthrotomy window. The fragments were held with reduction clamps followed by temporary fixation with 1.5-mm Kirschner’s wires. Two osseous tunnels were drilled from the distal to the proximal parts of the patella with a 2.4-mm drill bit or pin. The tunnels were drilled through the deeper half of the patella in the axial plane. A no. 5 Ticron suture (COVIDIEN, Norwalk, CT, USA) was passed through the tunnels via the guidance of a 26-gauge wire loop. The fractured patella was fixed with modified Lotke’s longitudinal anterior tension band (LAB) method (Fig. 1A and B). The knot was tightened with the modified Wagoner’s Hitch (Fig. 1C–G). The quadriceps tendon was split to the bone over the outlets of osseous tunnels for two reasons: allowing the suture to directly contact with the bone for a better fixation force and burying the knot beneath the quadriceps.

**Fig. 1.** (A and B). Transosseous suturing with No. 5 non-absorbable polyester suture by Lotke’s technique. (C–G) Step by step demonstration of modified Wagoner’s hitch [1]. (H) Intraoperative photograph after fixation revealed adequate inter-fragmentary compression. Twenty-six gauge wire loops were used as suture passers. K-wires were removed after tightening of the Wagoner’s hitch. (I) After fixation, the stability was checked by passive flexion of knee to maximum degree. The patient will start active range of motion exercise immediately if the fixation is stable enough.
tendon (Fig. 2A). Additional figure-of-eight tension-band sutures passing through the quadriceps tendon and the patellar tendon were applied in comminuted fractures or osteoporotic bone to enhance the fixation strength (Fig. 2B). The postoperative protocol was similar in both groups. The injured knees were immobilised with splints for 0–6 weeks postoperatively depending on the degree of comminution and the surgeon’s decision. The patients were regularly followed up and received radiographic evaluation every 2–4 weeks until achievement of bony union. The Orthopaedic Trauma Association fracture classification (AO/OTA) system was used to classify the fracture types. The average follow-up period within the two groups was 11.36 months, ranging from 3 to 18 months. Medical charts and radiographs were reviewed in both groups to assess the clinical need for implant removal, time to fracture healing, hospitalisation length, number of surgical procedures and complications. Healing of fracture was defined both clinically (no pain, no tenderness, ability to perform active straight leg rising and walk without aid) and radiographically (trabeculae connecting both major fragments) [25]. Radiographs of a case with transosseous suturing are shown in Fig. 3.

**Statistical analysis**

The Mann–Whitney U test was used to compare quantitative variables (time to union, operation time and hospitalisation days) between the two groups. We use non-parametrical statistical tests due to the non-normal distribution of our variables. The difference of the frequency distributions (fracture classification, number of procedures and complications, e.g., skin irritation and loss of reduction due to dislodgment of implants) between the two groups was compared with the chi-squared test or the Fisher’s exact test as indicated. All statistical analyses were performed with the SPSS software for Windows version 13.0 (SPSS Inc., Chicago, IL, USA).

**Results**

The transosseous suturing cohort comprised of 15 men and 10 women with an average age of 59.60 years (ranging from 34 to 84 years). After 1:1 matching of sex and age, there were no statistically significant differences between the two groups regarding fracture type, time to union and operation time (Table 1). Most of the fractured patellae within the two groups healed uneventfully except for two patients in the AO tension-band group who underwent revision surgery 3 weeks later due to implant dislodgement and loss of reduction. Eventually, both cases healed after the second surgery and the metal implants were removed after fracture healing due to irritation of skin. The mean hospitalisation length was 4.04 days in the transosseous suturing group and 5.76 days in the AO tension-band group, a difference which was statistically significant ($P < 0.001$) (Table 1). Regarding the number of procedures, all of the patients in the transosseous suturing group received only one procedure. In the AO tension-band group, 12 patients received one procedure, 11 patients had a second procedure for removal of implants and two patients received three procedures including revision surgery and removal of implants. The difference in procedure numbers reached statistical significance ($P < 0.001$) (Table 1). No infection or

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**Table 1**

<table>
<thead>
<tr>
<th></th>
<th>Transosseous suturing ($n=25$)</th>
<th>AO tension band ($n=25$)</th>
<th>$P$ values</th>
</tr>
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<tr>
<td>Age (M/F)</td>
<td>59.60 ± 14.26</td>
<td>61.32 ± 15.28</td>
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<tr>
<td>Sex</td>
<td>15/10</td>
<td>15/10</td>
<td>0.695*</td>
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<td>Fracture classification</td>
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<tr>
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<td>9</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>C1.3</td>
<td>5</td>
<td>6</td>
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</tr>
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<td>1</td>
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<tr>
<td>C2.2</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>C3.2</td>
<td>9</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Time to union (week)</td>
<td>8.43 ± 2.92</td>
<td>8.64 ± 2.82</td>
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<td>Operation time</td>
<td>69.00 ± 19.31</td>
<td>64.89 ± 14.27</td>
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<tr>
<td>Hospitalization days</td>
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<td>5.76 ± 1.50</td>
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<tr>
<td>Numbers of procedures</td>
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<tr>
<td>Complications</td>
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<tr>
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<td>12</td>
<td>0.001‡</td>
</tr>
<tr>
<td>Loss of reduction</td>
<td>0</td>
<td>2</td>
<td>0.490‡</td>
</tr>
</tbody>
</table>

† Chi-square tests.
‡ Fisher’s exact test.
§ Mann–Whitney U tests.
nonunion occurred within the two groups. Two patients in the transosseous suturing group were bothered by a subcutaneously palpable suture knot without pain. However, 12 patients in the AO-modified tension-band group exhibited migration of Kirschner's wires with painful irritation from the Kirschner's wire or wire knot. The frequency of skin irritation was significantly lower in the transosseous suturing group than in the AO modified tension-band group ($P = 0.001$) (Table 1). Loss of reduction due to migration of Kirschner's wires followed by dislodgment of tension-band wires occurred in two cases undergoing the AO-modified tension-band wiring. None of the patients in the transosseous suturing group experienced loss of reduction. The frequency of loss of reduction did not reach statistical significance ($P = 0.490$) (Table 1).

**Discussion**

Traditionally, the tension-band-wiring technique has been the most commonly used procedure for the treatment of displaced patellar fracture [17]. Previously, we used the AO-modified tension-band-wiring technique involving longitudinal Kirschner's wires and an 18-gauge stainless steel wire in a figure-of-eight pattern looped over the anterior patella as the standard procedure in our institute [22]. Biomechanical studies showed that the AO-modified tension-band wiring provided better inter-fragmentary compression than standard tension band, cerclage wiring or lag screws [8,13,23]. However, metal implant-related complications, such as migration of Kirschner's wires and prominent wire knots, are very common. Symptomatic hardware rates of up to 60% have been reported, often requiring hardware removal [5,17]. Smith et al. reported that within 87 patella fractures, displacement of ≥2 mm before healing was noted in 11 (9.6%) cases managed with modified anterior tension-band wiring [21]. In our series, the AO-modified tension-band-wiring group has a similar rate (2 in 25 cases) of fragment displacement, compared with no loss of reduction in the transosseous suturing group. Wu et al. reported bending both ends of Kirschner's wires to prevent migration. However, the skin may still be irritated by the ends of the Kirschner wires, which occurs due to reversion of the bent end [25]. Yotsumoto et al. used braided polyblend sutures and ring pins as tension-band fixation for the treatment of patellar fracture. Migration of the pins could be prevented by the suture passed through the ring pins; however, a second procedure is still needed to remove the implants [26]. Broken hardware in tension-band fixation is very rare but some catastrophic complications such as broken wire migration into the popliteal fossa and the right ventricle have been reported [1,8].

To avoid metal implant-related complications, clinical applications of metal-free techniques have been developed and studied [6,10,20]. Chatakondu et al. reported a preliminary result via the Pyrford technique using a circumferential cerclage suturing and an anterior suture looping through the quadriceps tendon with non-absorbable polyester [6]. Gosal et al. compared the AO tension-band-wiring technique using a stainless wire and a modified Pyrford technique using non-absorbable polyester [10]. Both presented a satisfactory outcome and a lower complication rate compared with the metal fixation group. However, there was lack of biomechanical evidence to determine the fixation strength of non-absorbable polyester with the Pyrford technique compared with the tension-band fixation. Regarding our fixation method, Lotke's anterior tension-band technique with a non-absorbable polyester suture has been biomechanically proved comparable to a modified tension-band method with a stainless steel wire [19]. The Wagoner's Hitch or Lorry Driver's Hitch is a traditional method used by lorry drivers to lash down loads and was found to have better inter-fragmentary compression effect in experimental studies [11,24]. To the best of our knowledge, clinical application of combining Lotke's technique with a non-absorbable polyester suture and the Wagoner's Hitch has not been reported in the English literature. Although the fixation strength of our novel technique has not been proved experimentally, the clinical results showed a convincing outcome in this study. Qi et al. reported a metal-free technique using bioabsorbable cannulated lag screws and braided polyester suture tension bands in treating patellar fractures resulting in satisfactory outcomes. The limitation of this technique is its relatively narrow application to patella fractures with adequate bone composition to accommodate screws [20]. Tissue reactions caused by bioabsorbable implants ranging from mild fluid accumulation to sinus formation to irreversible soft-tissue damage have also been reported [3,4,7,18]. Although severe tissue reaction is uncommon, when it occurs, it can be catastrophic.

In cases of comminuted fracture, we can use transosseous interfragmentary suturing to fix the small fragments so that they become large fragments. Lotke's suturing and the Wagoner's Hitch may then provide good inter-fragmentary compression and reconstruct the extensor mechanism. Additional figure-of-eight tension-band sutures passed through the quadriceps tendon and patellar tendon or circumferential sutures are useful in comminuted fracture or osteoporotic bone to enhance the fixation strength. Sometimes, the fracture is too comminuted and the fragments are too small to fix with sutures; thus, our method may be limited in that situation. However, the immobilisation period has shortened with improving surgical skill. We still have to protect comminuted fractures longer than simple transverse fractures in which the present technique might be a disadvantage relative to the tension-band-wiring technique.

The union time and operation time were not different in the two groups whereas the mean hospitalisation length in the suturing group was significantly shorter than in the AO-modified tension-band group. Excellent inter-fragmentary compression, early range of motion and lack of metal implant irritation may be the causes of difference.

We wish to emphasise some technical tips to achieve good result. First, the transosseous tunnels should be placed as deep as possible to purchase more bone mass and prevent tunnel failure caused by suture material breaking through the anterior surface of the patella, which was found in our experimental models during development of this technique. Second, the suture should closely contact the bone surface to achieve secure fixation and to avoid suture loosening after soft-tissue atrophy [5,20]. We routinely split the quadriceps tendon in the anterior–superior corner of the patella to eliminate soft-tissue interposition between suture and bone. Third, regarding the modified Wagoner's Hitch, if a certain distance is not maintained at the initial setting of the knot between the loop and the slip-knot (Fig. 1E), then the knot will tighten prematurely before maximum compressive force is attained. In addition, this knot is more likely to break if tightened prematurely [11]. Therefore, the surgeon performing this technique should practise several times on experimental bone models before applying it to patients. On the basis of our limited experience, excellent compression between fracture fragments can be achieved with the surgical tips we have mentioned above. Fourth, the knot should be securely buried beneath the quadriceps tendon to prevent prominent suture knots subcutaneously. In our series, there are two patients with a palpable suture knot over anterior surface of patella. Although the knots were not painful, they still caused a cosmetic problem, especially for young patients.

Our study has some limitations. In the prospective cohort, we used the Lysholm Knee Scoring Scale to evaluate the functional recovery. Although the visual analogue scale pain score was routinely recorded during every visit in our institute, we lacked the data of Lysholm knee scoring scale in the control group; therefore,
we cannot compare the functional outcome at the same postoperative period. More high-quality, double-blinded randomised controlled trials with greater case numbers are needed to confirm the advantages of the transosseous suturing technique.

Conclusion

Transosseous suturing of the patella has comparable results including union time and union rate compared with the traditional modified tension-band-wiring technique. The complications' rate is significantly lower than in the traditional technique. Obviously, our method does not require removal of the painful implants and can be applicable not only in transverse patellar fractures but also in selected comminuted fractures. The method may also be applicable in fixation of olecranon fractures with some modifications. As the result of transosseous suturing comparing favourably with the AO modified tension-band fixation, our method could be an alternative to the traditional technique.

Conflict of interest

No conflict of interest.

References
