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Vertical Interfragmentary Doubled Suture for Displaced Patella Fractures: Sequential Compressive Tightening with Nice Knot

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In the treatment of displaced patella fractures, open reduction and internal fixation is essential for patellofemoral congruency and restoration of the knee extension mechanism. Various surgical techniques and materials can be used, and their clinical outcomes are favorable. However, soft-tissue and skin irritation, pain, and limited range of motion due to metallic hardware can occur, and removal of hardware such as screws and K-wire may be required after bony union. We present a vertical interfragmentary suture technique for patella fractures using sequential compressive tightening with the Nice knot. This knot-tying technique is low profile, provides stable fixation enough to hold displaced fractures, and does not require a secondary procedure for hardware removal.

Keywords: *Patellar fracture, Vertical inter-fragmentary suture, Nice knot tie*

The goal of surgical treatment of patella fractures is to reestablish the extensor mechanism and restore articular congruence.[1-3] Various materials and methods have been applied for the fixation of patella fractures with high rates of treatment success. Proper selection of a construct to fix patella fractures is important because of its subcutaneous location and high level of force transmission during knee movement. Tension band wiring (TBW) has been commonly used for surgery of displaced patella fractures.[2] However, hardware irritation and the need for implant removal are often encountered after TBW. There are several issues to consider in association with the selection of the optimal fixation device: low-profile constructs to avoid soft-tissue irritation and biomechanical strength of a material to maintain patella fractures in position after treatment. Furthermore, improved fixation techniques could potentially reduce postoperative complications such as implant migration, loss of reduction, and painful hardware.

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We introduce a vertical interfragmentary suture technique using the Nice knot designed to achieve stable fixation of displaced patella fractures and reduce the need for implant removal. The Institutional Review Board of Gumi CHA Medical Center (IRB No. 2019136) reviewed and approved this study.

TECHNIQUE

A patient with a patella fracture (Fig. 1A) was positioned on a radiolucent table and a pneumatic tourniquet was used. A sharp dissection was carried down to the fracture site and medial and lateral full-thickness flaps were made to expose the extensor mechanism and the fracture site. The fracture plane and geometry were assessed through the traumatic tears in the medial and lateral retinaculum. The fractured surface was slightly inverted, and 3 or 4 drill holes were made using a 1.8-mm Kirschner wire, which was aimed from the fracture plane to the outer cortical border of the patella. Then, the polydioxanone (PDS) suture was passed in the bone tunnels through a 16-g spinal needle to facilitate shuttle relay of the suture material (e.g., FiberWire; Arthrex, Naples, FL, USA) (Fig. 1B and C). After doubled-over sutures were passed, the displaced fragments were anatomically reduced and held in posi-

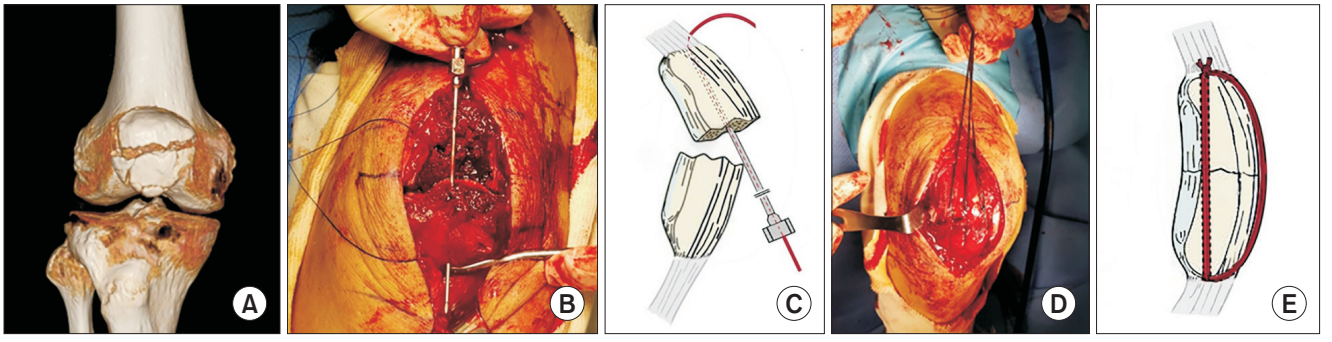

Fig. 1. (A) Three-dimensional computed tomography showing a displaced transverse patella fracture with comminuted fragments at the lateral margin and inferior pole. (B) After exposure of the fracture site and bone drilling, a polydioxanone (PDS) was passed through the 16-g spinal needle to facilitate the shuttle relay of the suture material in bone tunnels. (C) A schematic drawing of a sagittal cut image of the shuttle relay of the suture. A PDS was passed through the 16-g spinal needle. (D) The knots were slid down by pulling the 2 free limbs. The fracture site was sequentially secured by repeated sliding and tightening of the knots. (E) A final sagittal schematic drawing of the Nice knot tying on the patella fracture. The bone fragments were compressed against fracture by knots.

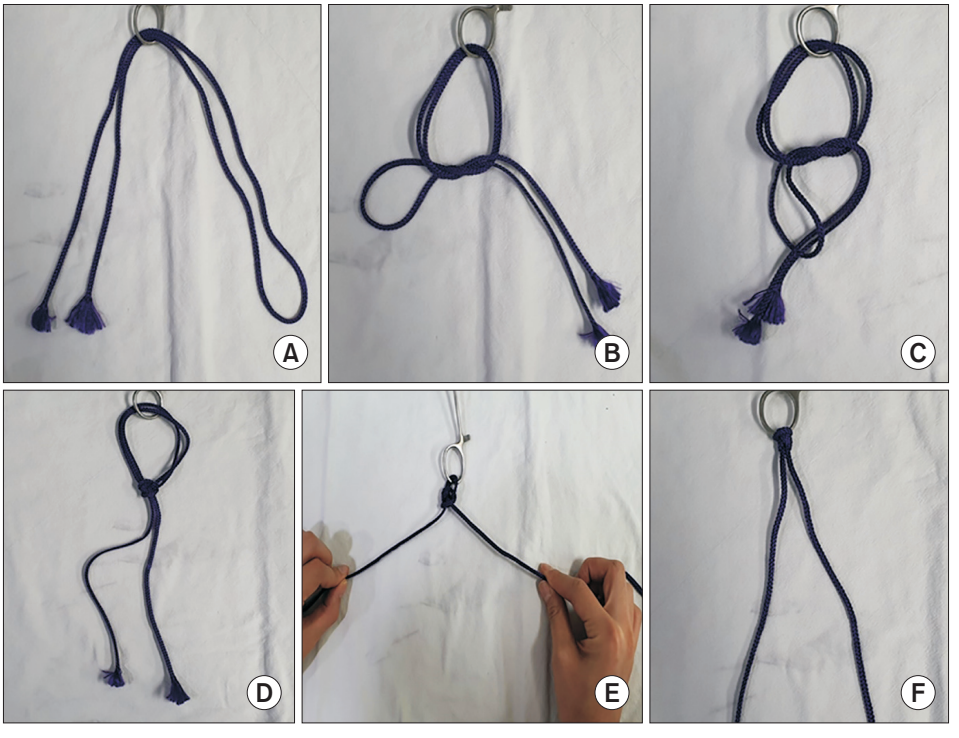

Fig. 2. (A) The braided suture was doubled over to obtain 2 free limbs on one end and a loop on the other. (B) The simple square knot was thrown using the loop on one hand and the 2 free limbs on the other. (C) The loop was opened and both free limbs were passed through it. (D) The knot was then dressed by making the loop smaller. (E) The knot was slid down by pulling the 2 free limbs apart. (F) To secure the knot, 3 alternating half hitches or surgeon's knots were performed using the 2 separated free limbs.

tion with a reduction clamp. We usually placed 3 or more sutures at an appropriate distance apart, depending on the fracture geometry (Fig. 1D). Temporary tightening of ties can be adjusted and fracture reduction can be corrected as needed before the knots are finally tightened and secured. In order to further compress the fracture site, we sequentially repeatedly slid and tightened the knots. Finally, to secure the knot, 3 alternating simple knots were made using the 2 separated free limbs. We placed knots at the superior margin of the patella to reduce soft-tissue irritation (Fig. 1E).

As in the Nice knot technique, the suture material was folded in half to get 2 free limbs at one end and a loop at the other end (Fig. 2A). At first, a square knot was made using the loop in 1 hand and the 2 free limbs in the other (Fig. 2B). Then, the free limbs were passed through an open loop (Fig. 2C). The knot was slid up to make the loop smaller (Fig. 2D). When ready to secure the knot after reduction of fracture, we tightened down the sliding knot by pulling both sides of free limbs apart (Fig. 2E). Fastening

process can be halted and resumed at any step, as the loop security of the knot prevents slippage. Finally, to secure the knot, 3 alternating simple knots were made using the 2 separated free limbs (Fig. 2F).

Joint congruity was verified with fluoroscopy and the final fixation stability was checked through a full range of knee movement. For the postoperative care, a long leg splint was applied for 2 or 3 weeks and full weight-bearing was allowed (Fig. 3). Then, we applied a hinged brace and allowed progressive knee flexion for the following 4 weeks. Unlike the fracture stabilization mechanism of TBW, fracture stabilization solely depends on the primary compression power of tightening tie, so early rehabilitation was avoided.

Fig. 3. The bony fragment was compressed against the fracture site with tied knots. After operation, plain radiography showed congruency of the joint line without the use of metallic hardware.

DISCUSSION

TBW using AO (Arbeitsgemeinschaft für Osteosynthesefragen) principles is the most widely accepted standard method of fixation for displaced transverse fractures. Beside TBW, there are various methods that can be used to fix patella fractures, including lag screw fixation, wiring through cannulated screws, vertical wiring, and their combinations.[1,4-6] Each of these methods has its own advantages and disadvantages. Most of these constructs are placed over the anterior aspect of the patella and make fracture more stable when the knee joint is flexed, but soft-tissue and skin irritation due to implants are reported as postoperative complications.[7] Due to the thin subcutaneous tissue over the anterior aspect of the knee, the implant can cause pain during joint movement and may restrict the knee movement range. Hardware irritation resulting in the need for removal is a frequent complication after treatment, with an incidence of 23% to 52%.[2,8,9] Therefore, strong, low-profile constructs are necessary to diminish implant migration, loss of reduction, and painful implant.[7,9,10]

Recognition of these complications and limitations led to the search of alternative fixation materials to reduce reoperation rates. Wright et al.[11] reported that FiberWire showed a higher failure strength than the stainless steel wire in the maintenance of a tension band under force. Recently, Bryant et al.[5] reported there was no difference in biomechanical properties in fracture displacement and load to failure between FiberWire and stainless steel wire.

Nice knot tying is a secure suture fixation technique introduced by Boileau et al.[4] It is an easy-to-perform, self-secured, adjustable, solid technique, which combines a double suture with a sliding knot. It can be applied to fix torn tendons, ligaments, and fractured bones in both open and arthroscopic surgery. This technique has several

Table 1. Patient Demographics

Case	Age (yr)/ sex	Type of injury	Fracture location	No. of Nice knot ties	Follow-up (mo)	Union time (wk)	ROM at final FU	F-VAS	Removal of ties	Complication
1	62/F	Slip down	Inferior pole	3	12	11	0–130	0	No	-
2	45/M	TA	Transverse body	3	16	14	5–130	1	No	Superficial infection
3	58/M	TA	Transverse body	4	13	13	0–140	0	No	-
4	67/F	Slip down	Transverse body	3	12	15	10–130	2	No	Preexisting PF arthritis
5	72/F	Slip down	Transverse body	3	14	12	10–110	2	No	Delayed union
6	65/F	Fall down	Inferior pole	3	15	12	0–130	0	No	-

ROM: range of motion, FU: follow-up, F-VAS: final visual analog scale, TA: traffic accident, PF: patella-femoral.

advantages. First, the doubled-over suture doubles the suture strength. As the tension in each strand is halved, the risk of failure is decreased as well. Using a double-folded, braided material increases internal suture friction, which translates into excellent loop and knot security. Second, knot tying can be easily performed by pulling the free limbs apart, and the process can be adjusted at any step as the internal suture friction prevents slippage. This allows accurate, adjustable tensioning of the suture. Therefore, temporary tying and adjusting for fracture reduction can be performed as required before the final knot securing. Third, the Nice knot remains low profile compared to the metallic hard device and causes less irritation to surrounding tissues. It provides sufficient holding security without excessive complexity and bulkiness.[4)]

We performed a vertical interfragmentary suture with Nice knot tying using a nonabsorbable suture instead of classical TBW in 6 cases of displaced transverse patella fractures as a pilot study (Table 1). There were 4 transverse body fractures and 2 inferior pole fractures. The fractures were relatively easy to reduce and fix due to the lack of comminution or multiple fragmentation. In this technique, postoperative stability depends on the compression force of the ties and the configuration of the fracture plane. If a fracture has comminuted fragments or is crushed, it will be difficult to obtain sufficient strength to withstand the tensile force after the procedure. Hence, our procedure is amenable for simple transverse fractures than severely comminuted patella fractures.

In our pilot study, we achieved solid bony union without soft-tissue irritation, and there was no need for a further operation to remove the securing materials. The Nice knot tying can be an easy-to-perform, alternative technique for the treatment of patella fractures, particularly for displaced simple transverse patella fractures.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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