A Heart-shaped Sleeve Simplifies Intramedullary Tibial Nail Insertion when Using the Suprapatellar Approach

Kosuke Tajima,^{1,2} Chikako Shimizu,² Soichiro Ohno,² Yusho Nishida,² Kazuhiko Udagawa² and Junichi Sasaki²

¹*Department of Emergency Medicine, Fujita Health University Hospital, Aichi, Japan*

²*Department of Emergency and Critical Care Medicine, Keio University School of Medicine, Tokyo, Japan*

(Received for publication on January 24, 2017)

(Revised for publication on June 21, 2017)

(Accepted for publication on June 22, 2017)

(Published online in advance on July 15, 2017)

The suprapatellar approach for intramedullary tibial nailing has become widely accepted over the past decade. A round sleeve is passed beneath the patella to protect the surface of the patellofemoral joint (PFJ). However, the round sleeve cannot be easily stabilized in the PFJ because it does not conform to the shape of the patellar apex. Consequently, we produced a heart-shaped sleeve to simplify the insertion of the entry sleeve during the suprapatellar approach. Using the new sleeve, the following procedure is used: (1) make a longitudinal 4 cm skin incision proximal to the patella to reach the PFJ, (2) insert the guide pin manually to the ventral edge of the tibial plateau, (3) insert the cannulated trocar along the guide pin, (4) insert the heart-shaped sleeve along the cannulated trocar, (5) remove the cannulated trocar, (6) ream the entry point through the heart-shaped sleeve. Then, continue insertion of the nail in the standard manner. Among 44 patients (29 men, mean age 45.6 years, range 26–87 years) with tibial fractures treated between 2010 and 2015, the first 18 consecutive cases were performed using a round sleeve and the rest were performed using the heart-shaped sleeve. The surgery time until entry reaming commenced was 8.9 min (range 6–12 min) using the round sleeve and 6.2 min (range 3–12 min) using the heart-shaped sleeve ($P < 0.05$). The heart-shaped sleeve is easily stabilized in the PFJ and greatly simplifies the intramedullary nailing of tibial shaft fractures using the suprapatellar approach. (DOI: 10.2302/kjm.2017-0001-OA; Keio J Med 67 (1) : 10–16, March 2018)

Keywords: suprapatellar approach, intramedullary tibial nailing, patellofemoral joint, heart-shaped sleeve

Introduction

Intramedullary nailing is widely accepted as the standard surgical procedure in treating tibial fractures. Intramedullary nails are most commonly inserted using the infrapatellar transtendon approach with the patient's hip and knee flexed. However, this approach can lead to problems achieving adequate X-ray monitoring, and an assistant surgeon is required to maintain the appropriate reduction while the nail is inserted. Furthermore, this procedure is sometimes associated with anterior knee

pain.

Since Cole¹ (2006) and Reucker² (2009) reported the technique for a suprapatellar approach (SPA) with the knee in a semi-extended position to overcome these problems, SPA has been widely adopted. SPA, simplifies the fracture reduction and facilitates intraoperative C-arm visualization and nail insertion. Although invasion to the patellofemoral joint (PFJ) articular surface during SPA does not usually result in major damage clinically,^{3,4} the surgeon must exercise care in protecting the patellofemoral articular surface because the long-term outcomes of

Fig. 1 Usual insertion of the trocar in SPA.

(A) The trocar should be placed in the patellar groove of the PFJ. (B) Enlarged view of the PFJ. (C, D) If the patella subluxates laterally, the sleeve is displaced in the opposite direction.

the procedure have not yet been established.

In SPA, insertion of the trocar into the PFJ is often troublesome,⁵ because the round trocar is incompatible with the shape of the ridge of the patella (**Fig. 1A, B**). Even if the trocar is inserted properly, if the patella should subluxate laterally (or medially), the restoring force of the patellar thrust will move the sleeve laterally (**Fig. 1C, D, Animation1**). Because the entry point determines the position of the nail in the intramedullary nailing, it is crucial to locate the entry hole in the correct position. Consequently, any instability of the trocar is a cause of great concern during the operation. To solve this problem and to simplify insertion of the entry sleeve when using SPA, we developed a PFJ protection sleeve that is heart shaped in cross section (**Fig. 2**), and additionally produced a cannulated trocar. The heart-shaped sleeve was designed considering the shape of the joint surface, the patellar facet angle, and the sulcus angle. The tip of the sleeve is gradually tapered so as not to damage the joint surface during insertion. Using a guide-pin-first approach with the heart-shaped sleeve will simplify the whole procedure and also help to reduce fracture malalignment.

SPA Surgical Techniques Using the Heart-Shaped Sleeve: A Guide-Pin-First Method

In conventional SPA, a round sleeve and trocar is inserted before placing the guide pin; however, inserting the sleeve is not easy.^{6,7} In our novel method, we first carefully insert the guide pin, and then the following procedure can be performed without any major difficulties (**Animation2**):

- (1) Make a 4-cm longitudinal skin incision, one finger breadth above the superior pole of the patella.
- (2) Sharply dissect the patellofemoral compartment of the quadriceps to the joint capsule.
- (3) Carefully insert a 3.2-mm guide pin through the PFJ manually, while protecting the articular surface of patella with the finger (**Fig. 3A**). Although the guide pin is usually guided to the appropriate starting point by the shape of the femoral trochlear groove, the entry point should be confirmed using biplanar C-arm imaging. [In the anteroposterior (AP) view, the entry point is in line with the axis of the intramedullary canal and with the lateral tubercle of the intercondylar eminence. In the lateral view, the entry point is at the ventral edge of the tibial plateau (**Fig. 4**).]
- (4) After definitive placement of the guide pin, insert the

Fig. 2 Heart-shaped sleeve and cannulated trocar.

(A-C) Sketches of the heart-shaped sleeve. (D) Photograph of the heart-shaped sleeve. (E,F) Cannulated trocar for the guide-pin-first method.

cannulated trocar over the guide pin (**Fig. 3B**).

(5) Insert the heart-shaped sleeve over the trocar (**Fig. 3C**).

(6) Remove the cannulated trocar (**Fig. 3D**).

(7) Insert the entry reamer through the heart-shaped sleeve along the guide pin, and create the entry hole for the nail (**Fig. 3E**).

After creating the entry hole, the nail is inserted in the standard manner. The trocar and the heart-shaped sleeve should be gently inserted and carefully located during the entire procedure so as not to damage intra-articular chondral surfaces of the PFJ.

Animation videos are available in the on-line version only.

Animation 1 : Ordinary technique of SPA

Animation 2 : SPA using the heart-shaped sleeve and the guide-pin-first method

Comparison of Surgery Times Using the Heart-Shaped Sleeve and the Round Sleeve

The study was approved by the ethics committee of Keio University Hospital and Fujita Health University. Among 44 patients (29 men, mean age 45.6 years, range 26–87 years) with tibial fractures treated between 2010 and 2015, the first 18 consecutive cases were performed using a round sleeve and the rest were performed using the heart-shaped sleeve. The surgery time until entry reaming commenced was compared in these two groups.

Results

The surgery time until entry reaming commenced was 8.9 min (range 6–12 min) using the round sleeve and 6.2 min (range 3–12 min) using the heart-shaped sleeve ($P < 0.05$) (Fig. 5). The surgery time until entry reaming commenced decreased on average by 2.7 min when using the guide-pin-first approach with the heart-shaped sleeve. Moreover, as can be seen in the abovementioned videos and in the video of the entire novel procedure (available at <http://www.fujita-hu.ac.jp/~fujitaqq/sdc5.mov>), the technical complication has been greatly decreased.

Case 1

A 33-year-old man was hit by a car and suffered a Gustilo type 3A tibial fracture (Fig. 6A). Debridement and external fixation was performed immediately (Fig. 6B,C). The tibia had suffered a multiple segmented fracture. To maintain the reduction during surgery and to avoid perforating the posterior cortex of the proximal tibia with the nail, an Expert Tibial Nail (Synthes) was inserted using SPA (Fig. 6D,E). The fracture healed within 10 months, and the nail was removed 18 months after the first operation (Fig. 6F).

Discussion

In 1996, Tornetta and Collins⁸ reported a semi-extended position of the knee during an open medial parapatellar arthrotomy, a procedure aimed at solving the problem of malalignment of tibial fracture. In 1998, Cole⁹ advocated a limited medial parapatellar arthrotomy with retraction of the patella lateral to the femoral sulcus. Finally, in late 2007, Tornetta and Ryan¹⁰ revised the semi-extended po

Fig. 3 Overview of the guide-pin-first method and use of the heart-shaped sleeve.

(A) A 3.2-mm guide pin is gently insert through the PFJ manually. (B) A cannulated trocar is inserted over the guide pin. (C) The heart-shaped sleeve is placed the over the previously located trocar. (D) The cannulated trocar is removed. (E) The entry reamer is inserted through the heart-shaped sleeve to create the entry hole.

Fig. 4 Macroscopic (A) and fluoroscopic view (B) of the guide pin. The entry point in the lateral view is at the ventral edge of the tibial plateau.

sitioning to a minimal 2.5-cm medial skin incision proximal to the patella. This percutaneous minimally invasive intramedullary nailing technique is a proven fixation mode for fracture stabilization in tibial shaft fractures. However, it is much easier to pass the trocar through the PFJ in a full extended knee position, a procedure that we perform preferentially.

Intramedullary nail insertion in the knee extended position has several clinical merits. (1) In the classic nailing procedure, an assistant is needed to reduce the fracture and to maintain the appropriate position until the nail has traversed the fracture site. With SPA, reduction and the nailing procedure is easily completed, and an assistant surgeon is not required. During nail insertion using SPA, there is no danger of posterior cortical perforation, a complication that was occasionally seen when using the classic parapatellar or patellar tendon-splitting approach. (2) C-arm visualization in both the AP and lateral planes during nail insertion is mandatory to avoid further fragmentation or deformity. However, obtaining adequate intraoperative radiographic imaging is challenging in conventional intramedullary nailing with hip and knee in a flexed position. SPA facilitates two-plane C-arm visualization. It avoids the need to change the position of the leg during reduction and nail insertion. (3) In proximal tibial fracture, the knee flexion can lead to apex anterior angulation secondary to over-pull of the quadriceps muscle. However, the extended position of SPA relaxes the quadriceps muscle, preventing procurvatum deformity. (4) The classic parapatellar and transtendon approaches are associated with postoperative anterior knee pain, which is one of the most common complaints after tibial intramedullary nailing. Court-Brown¹¹ found the incidence of

Fig. 5 Surgery time until entry reaming commenced. The procedure using the heart-shaped sleeve reduced the surgery time until reaming.

anterior knee pain to be 56% when using the classic approach. Keating¹² compared knee pain after parapatellar and patellar tendon-splitting approaches. They found that 77% of patients developed knee pain after a tendon-splitting incision, whereas only 50% developed pain with a parapatellar approach. SPA has the potential to reduce the incidence of anterior knee pain. The infrapatellar nerve is well protected and not at risk of injury when using this

Fig. 6 A 33-year-old man suffered a Gustilo type 3A tibial fracture (A). Debridement and external fixation was performed immediately (B,C). A tibial nail was inserted using SPA (D,E). The nail was removed 18 months after the injury (F).

approach. Additionally, soft tissue scar formation will not form on the anterior knee, but superior to the patella, which may reduce pain on kneeling. SPA also has the advantage of allowing the use of a patellar tendon weight-bearing brace, because the surgical scar is not located in the anterior knee.

Despite these merits of SPA, insertion of the trocar in the PFJ is often troublesome because the traditional round trocar is incompatible with the shape of the ridge of the patella, meaning that the round sleeve cannot be stabilized in the appropriate position. It is crucial to create an entry hole in the correct location in intramedullary nailing. However, if the patella subluxates laterally (or medially), the restoring force of the patella displaces the sleeve.

To solve this problem, we produced a heart-shaped sleeve, taking into consideration the shape of the joint surface, the patellar facet angle (on average 130°) and the sulcus angle (on average 140°). The tip of the sleeve is gradually tapered so as not to injure the joint surface during insertion. As a result, the heart-shaped sleeve is easily stabilized in the PFJ because of its specially designed shape.

Furthermore, we produced a cannulated trocar to simplify the whole procedure. In conventional SPA, a round sleeve and trocar is inserted before inserting the guide pin. In contrast, in our novel method, the guide pin is carefully inserted through the PFJ first (the so-called “guide-pin-first method”). The cannulated trocar is then inserted over the guide pin, and the heart-shaped sleeve is inserted over the trocar. This procedure is analogous to the Seldinger technique used when inserting intravenous catheters. With our novel heart-shaped sleeve and the guide-pin-first method, the whole procedure can be performed simply.

The percutaneous suprapatellar technique reduces the risk of perforating the posterior cortex of the tibia, helps to reduce varus or valgus deformities by using the femoral trochlear groove as a guide to the entry point of the nail, and simplifies the acquisition of intraoperative radiographs using a C-arm because there is no need to change the position of the leg during reduction and nail insertion. Moreover, SPA is easily mastered, and has no disadvantages compared to classic tibial nailing.^{13–16} Although the invasion to the PFJ are reported minimally invasive,^{3,4} SPA still has the potential to damage the PFJ. However, our heart-shaped sleeve has a better fit to the PFJ than the ordinarily used sleeves, and therefore causes less damage to the joint cartilage.

Although prospective randomized controlled trials are required to confirm the benefits of the SPA technique, we are confident that SPA has many advantages. The novel heart-shaped sleeve and the guide-pin-first method described here greatly simplify the whole SPA procedure and are likely to provide beneficial outcomes for intramedullary nailing of tibial shaft fractures.

Conflicts of Interest

There are no conflicts of interest to declare.

References

1. Cole JD: Distal tibia fracture: Opinion: intramedullary nailing. *J Orthop Trauma* 2006; **20**: 73–74. PMID:16424816, DOI:10.1097/01.bot.0000196658.55293.e6
2. Ruecker AH, Hoffmann M, Rupprecht ME, Rueger JM: Distal tibial fractures: intramedullary nailing. *Eur J Trauma Emerg Surg* 2009; **35**: 520–526. PMID:26815374, DOI:10.1007/s00068-009-9185-y
3. Eastman J, Tseng S, Lo E, Li CS, Yoo B, Lee M: Retropatellar technique for intramedullary nailing of proximal tibia fractures: a cadaveric assessment. *J Orthop Trauma* 2010; **24**: 672–676. PMID:20926965, DOI:10.1097/BOT.0b013e3181c1d675
4. Gelbke MK, Coombs D, Powell S, DiPasquale TG: Suprapatellar versus infra-patellar intramedullary nail insertion of the tibia: a cadaveric model for comparison of patellofemoral contact pressures and forces. *J Orthop Trauma* 2010; **24**: 665–671. PMID:20926959, DOI:10.1097/BOT.0b013e3181f6c001
5. Ordinary technique of Suprapatellar approach, <http://www.fujita-hu.ac.jp/~fujitaqq/sdc1.mov>, Accessed on June22 2017
6. Surgical techniques using the Guide-pin-first method with Heart-Sleeve, <http://www.fujita-hu.ac.jp/~fujitaqq/sdc4.mov>, Accessed on June22 2017
7. Guide-pin-first method with prototype of HeartSleeve, <http://www.fujita-hu.ac.jp/~fujitaqq/sdc5.mov>, Accessed on June22 2017
8. Tornetta P III, Collins E: Semiextended position of intramedullary nailing of the proximal tibia. *Clin Orthop Relat Res* 1996; **185**–189. PMID:8653954, DOI:10.1097/00003086-199607000-00029
9. Cole JD: Intramedullary fixation of proximal tibial fractures. *Tech Orthop* 1998; **13**: 27–37. DOI:10.1097/00013611-199801000-00004
10. Tornetta P III, Ryan S: Tibial metaphyseal fractures: nailing in extension. Paper presented at: Orthopaedic Trauma Association 24th Annual Meeting; October 16–18, 2008; Denver, Colorado.
11. Court-Brown CM, Gustilo T, Shaw AD: Knee pain after intramedullary tibial nailing: its incidence, etiology, and outcome. *J Orthop Trauma* 1997; **11**: 103–105. PMID:9057144, DOI:10.1097/00005131-199702000-00006
12. Keating JF, Orfaly R, O'Brien PJ: Knee pain after tibial nailing. *J Orthop Trauma* 1997; **11**: 10–13. PMID:8990026, DOI:10.1097/00005131-199701000-00004
13. Courtney PM, Boniello A, Donegan D, Ahn J, Mehta S: Functional knee outcomes in infrapatellar and suprapatellar tibial nailing: Does approach matter? *Am J Orthop* 2015; **44**: E513–E516. PMID:26665254
14. Zelle BA, Boni G, Hak DJ, Stahel PF: Advances in intramedullary nailing: Suprapatellar nailing of tibial shaft fractures in the semiextended position. *Orthopedics* 2015; **38**: 751–755. PMID:26652323, DOI:10.3928/01477447-20151119-06
15. Sanders RW, DiPasquale TG, Jordan CJ, Arrington JA, Sagi HC: Semiextended intramedullary nailing of the tibia using a suprapatellar approach: radiographic results and clinical outcomes at a minimum of 12 months follow-up. *J Orthop Trauma* 2014; **28**(Suppl 8): S29–S39. PMID:25046413, DOI:10.1097/01.bot.0000452787.80923.ee
16. Gaines RJ, Rockwood J, Garland J, Ellingson C, Demaio M: Comparison of insertional trauma between suprapatellar and infrapatellar portals for tibial nailing. *Orthopedics* 2013; **36**: e1155–e1158. PMID:24025006, DOI:10.3928/01477447-20130821-17