



Original Research

Arthroscopic Retrograde Intramedullary Nailing of Periprosthetic Fractures After Total Knee Arthroplasty—Technique, Safety, and Outcomes

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ABSTRACT

Background: Periprosthetic fractures after total knee arthroplasty are notoriously challenging entities to manage. The 2 major fixation techniques utilized include locking compression plates and retrograde intramedullary nailing. The challenges in obtaining correct entry points in the presence of the superimposing femoral component in retrograde intramedullary nailing often warrants a full knee joint arthroscopy. Thus, the purpose of this first series is to describe the arthroscopy-assisted retrograde intramedullary nailing (ARIN) technique and evaluate clinical results and potential risks and benefits.

Methods: This was a retrospective review of prospectively collected data obtained from 16 patients treated with the ARIN technique. Data obtained included operative time, size of incision, and intra-operative complications. In the postoperative course, patients were assessed for time to union, functional outcomes using the Knee Society Score, and the presence of complications.

Results: Nine male and 7 female patients were included with a mean age of 70.8 years. The patients were followed up for a minimum of 24 months. The mean operative time was 86.5 minutes. Union was achieved in all fractures with an average union time of 15.9 weeks. The mean Knee Society Score obtained at 2 years postoperatively was 84.6. No major complications were documented during the follow-up period. None of the cases required conversion to the conventional open technique.

Conclusions: The ARIN technique has demonstrated results comparable with those from previous resources. Although results from this series suggest that the utilized technique is safe and offers a less invasive approach, direct clinical comparisons in larger scale trials are required.

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Introduction

Periprosthetic fractures after total knee arthroplasty (TKA) are notoriously challenging entities to manage. Coupled with an increasingly aging population, the increase in TKA has been accompanied by a predictable rise in postoperative complications, including periprosthetic fractures [1]. Two major techniques are utilized in the management of supracondylar femoral periprosthetic fractures: locking compression plates and, to a lesser extent, retrograde intramedullary nailing (RIMN) in the presence of a compatible, open-box femoral component.

Both techniques demonstrate similar overall outcomes, with equivalent union rates and functional scores [2,3]. An inclination toward RIMN may be due to the potential advantages which include biomechanical superiority, ability for early weight-bearing, smaller incisions, and minimal soft-tissue disturbance [4]. Furthermore, as opposed to the iliotibial band irritation seen with the use of locking compression plate, the nature of the intramedullary implant is unlikely to necessitate its removal [5]. In addition, the compatibility of the femoral component and the intramedullary nail is pertinent to the preoperative decision-making process as thoroughly summarized by Jones et al. [6].

Yet there are several challenges to RIMN in femoral supracondylar periprosthetic fractures. First, a correct entry using fluoroscopy is complicated by the superimposed femoral component, often warranting a full knee joint arthroscopy to confirm the appropriate entry site. Inappropriate entry points carry a risk of

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recurvatum deformities, resulting in severe limitations in knee flexion. Second, damage to the polyethylene tibial post is possible, and reaming without direct visualization may jeopardize the integrity of the post. These challenges have led to the utilization of the arthroscope to assist in accurately delineating entry points and aid direct visualization of the knee joint, allowing for a less invasive procedure sparing the patient an arthrotomy.

The purpose of this series is to describe the arthroscopy-assisted retrograde intramedullary nailing (ARIN) technique and evaluate clinical results and potential risks and benefits. We hypothesize that the arthroscopic technique is safe, less invasive, and allows for direct visualization without the need for an arthrotomy.

Material and methods

Study design and patient selection

We performed a retrospective review of prospectively collected data from patients diagnosed with supracondylar femoral peri-prosthetic fractures after posterior stabilizing and cruciate retaining (CR) TKA between January 2016 and December 2019, who were treated with the ARIN technique. All surgeries were performed by a single senior revision arthroplasty consultant (A.A.) in a single tertiary orthopedic center. Informed consent was obtained from all participants included.

Outcome assessments

Data were obtained on intraoperative variables including Orthopedic Trauma Association fracture classification, operative time, size of incision, and intraoperative complications. In the postoperative course, patients were assessed for time to radiographic union and functional outcomes at 2 years postoperatively using the Knee Society Score [7]. Patients were further evaluated for complications including superficial or deep infection, loosening of components, and the presence of deformities.

Operative technique

The patient is positioned supine on a radiolucent fracture table along with a radiolucent wedge to allow flexion of the knee at 90° to overcome deforming forces and aid in fracture reduction (Fig. 1). The procedure begins with a standard anterolateral knee arthroscopy portal and passage of the arthroscope into the joint. Next, routine inspection of the knee, femoral component, and box is carried out. Normally, adhesiolysis and clearing of debris are

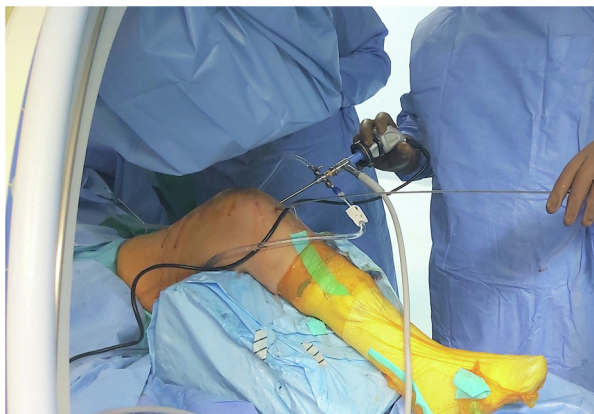


Figure 1. General setup of patient positioning with the leg flexed over a radiolucent triangular wedge, arthroscopic portal, image intensifier, and guidewire insertion.

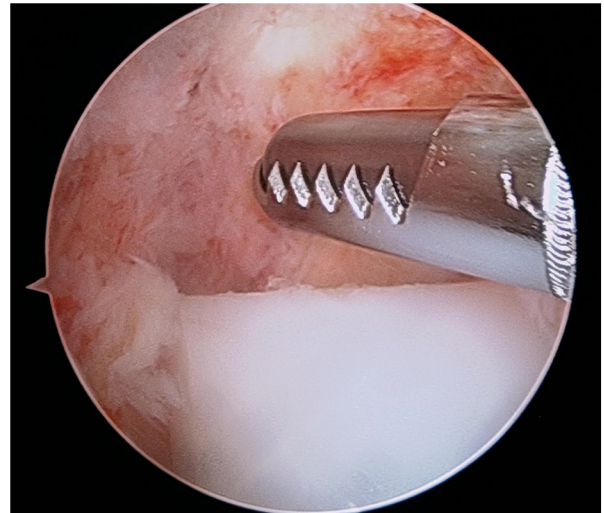


Figure 2. Inspection of the tibial polyethylene post and adhesiolysis using a shaver to clear the entry point.

required to adequately inspect all the respective components (Fig. 2). The polyethylene post is inspected for damage and possible wear and tear.

Once the entry point is visualized and the region cleared, a 2-cm midline incision is made just below the lower pole of the patella, and the patellar tendon is split. A guide wire is inserted under direct scope-vision. The entry point is directly visualized to allow a safe distance from the femoral component and the polyethylene post (Fig. 3). After acceptable fracture reduction, the guide wire entry position is confirmed via an image intensifier.

The guide wire is then replaced with a ball-tip guide rod. The reaming is initially performed under scope-vision, ensuring no contact is made with both the tibial polyethylene post and the femoral prosthesis. The intramedullary canal is then reamed to the level of the lesser trochanter, and an appropriately sized retrograde supracondylar nail is inserted (Fig. 5).

The nail is positioned appropriately in the distal segment to allow interlocking screw insertion. Furthermore, positioning of the

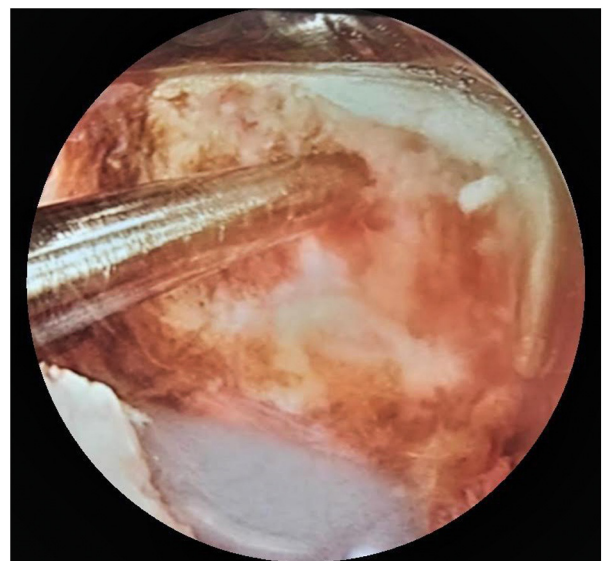


Figure 3. Central entry point using a guidewire with a clear distance from the tibial polyethylene post and femoral component.

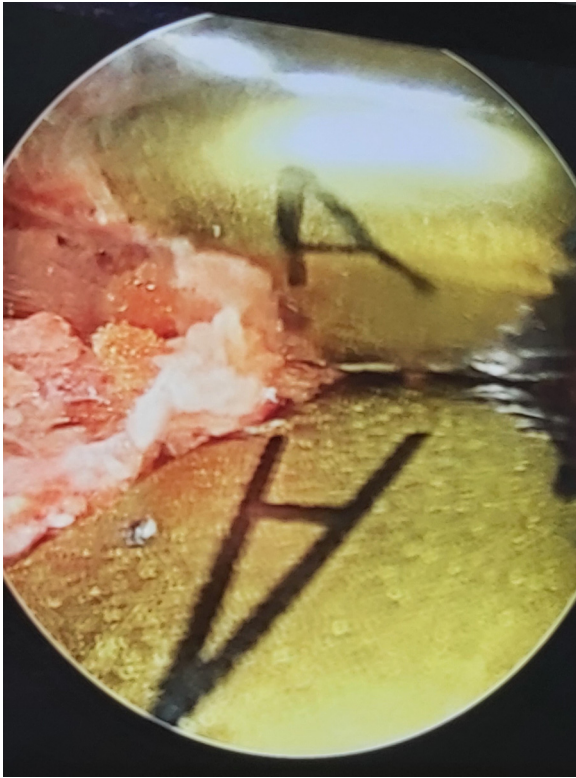


Figure 4. The “Mirror sign”.

nail flush into the intercondylar notch avoids tibial post damage by a protuberant nail (Fig. 5). The nail placement depth and position in flexion/extension are assessed for potential impingement on the tibial post. The proximal and distal interlocking screws are inserted in the usual fashion. After reaming and insertion of the nail, the knee joint is thoroughly irrigated using the scope pump/suction system and afterward irrigated through the incision.

At this point, the arthroscope is removed, the patellar tendon is repaired, and incisions sutured (Fig. 5). Postoperative radiographs are obtained to ensure adequate reduction, alignment, and the absence of deformities. Follow-up radiography and postoperative rehabilitation are performed in the usual manner with early weight mobilization as tolerated after 2-3 weeks of range-of-motion exercises (Fig. 6). An example of follow-up radiographs showing union in the absence of deformity are shown Figure 7.



Figure 6. Final incision size measuring less than 3 cm.

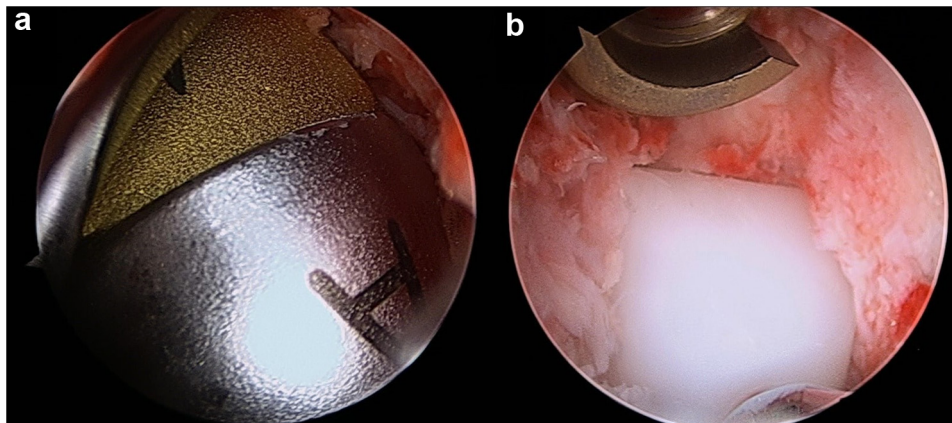


Figure 5. (a) Visualization of the insertion of the nail to assess depth. (b) Retrograde nail inserted and a view of the inferiorly related tibial polyethylene post.

Table 1
Technical tips while utilizing the technique.

| |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ensure at least 90 degrees of knee flexion is possible—this will aid visualization of the tibial post and the correct entry point. |
| Expertise in arthroscopy is necessary for adequate orientation in the presence of the components and subsequent “Mirror” effect (Fig. 4). Note: Mirror effect is diminished in the presence oxidized zirconium implants. |
| Adhesions may be present upon arthroscopic entry. Adhesiolysis is recommended before proceeding. |
| If the PS femoral component box is closed with the central plastic plug, all efforts must be made to remove the cap. |
| In cruciate retaining knees, care must be taken to avoid injury to the PCL, as the PCL may complicate efforts to attain an appropriate entry point. |
| The nail must be flush into the intercondylar notch under direct visualization to ensure distal screws can be placed appropriately and that the nail does not impinge on the tibial post—this may be done by direct visualization of knee flexion and extension. |

PS, posterior stabilized; PCL, posterior cruciate ligament.

Results

Technical tips that may aid in the utility of the technique are displayed in Table 1. We identified 16 patients who were managed using the ARIN technique. Characteristics of our study population and outcome measures are summarized in (Table 2). Nine male and 7 female patients were included with a mean age of 70.8 years (range 64–79 years). The majority of fractures were classified as Orthopedic Trauma Association 33A1 (n = 9), while the remainder were 33A2 (n = 5) and 33A3 (n = 2). All patients were followed up for a minimum of 24 months (mean = 35 months, range = 24–49 months).

The mean operative time was 86.5 minutes (range 65–125 minutes). Union was achieved in all fractures with an average union time of 15.9 weeks (range 9–23 weeks). Two patients healed with extension malunion of 10–15 degrees, and 1 of these patients had a CR knee replacement. The mean Knee Society Score obtained at 2 years postoperatively was 84.6 (range 79–92). None of the cases were complicated by infection, compartment syndrome, reoperation, and component loosening or implant breakage. Five patients had a nail size of 10 mm, 9 patients had 10.5 mm, and 2 patients had 11 mm. All patients returned to their preinjury baseline level of mobility at 1 year postoperatively. All cases were successfully completed arthroscopically, without the need for conversion to the conventional technique.

Discussion

Periprosthetic supracondylar femoral fractures remain complex entities to manage due to the multifaceted nature of both; the elderly patient and the osteopenic fracture. The conflicting evidence on the optimal management of these fractures manifests a

lack of clear consensus. In our series, arthroscopic retrograde nailing was performed for both CR and posterior stabilizing prosthesis containing an open box amenable to RIMN.

Results from this first series on the ARIN technique for periprosthetic fractures after TKA demonstrate outcomes comparable with previous literature evaluating retrograde nailing, especially when comparing functional scores, union rates, and complications [2,3,8,9]. Our series did not document any case of nonunion, severe malalignment, or infection, which perhaps suggests noninferiority with regard to major complications. Although we documented 2 cases of extension malunion, these were anticipated events inherent to retrograde nailing in periprosthetic fractures and did not present with any negative sequelae [10,11].

The ARIN technique possesses several hypothetical advantages. The technique negates the necessity for a large midline incision and a full knee joint arthrotomy. The minimally invasive approach may diminish the risk of infection, decrease blood loss, reduce post-operative pain associated with a large wound, and potentially allow earlier recovery and rehabilitation. In addition, arthroscopy may serve to confirm whether or not a retrograde nail is compatible with the implant in situ. This is particularly useful in light of the numerous new TKA designs and the in the absence of adequate operative reports.

Furthermore, the arthroscope allows for direct visualization of knee joint, allowing the surgeon to ensure the entry point and depth of the nail are ideal. Visualization also aids in safeguarding the polyethylene post (Fig. 8) during the entire procedure with particular focus on reaming and nail impingement. The utilization of fluoroscopy may be reduced and reserved only for confirmation of adequate reduction and alignment.

However, there are potential challenges with the use of the ARIN technique. In the management of these fractures, the tibial

Table 2
Outcomes and characteristics of the study population.

| Case no. | Prosthesis type | Sex/ Age | AO/OTA classification | Lewis and rorabeck classification | Operative time (min) | Union time (wk) | Knee society score | Follow-up period (mo) | Range of motion (degrees) |
|----------|-----------------|----------|-----------------------|-----------------------------------|----------------------|-----------------|--------------------|-----------------------|---------------------------|
| 1 | PS | M/67 | 33A1 | II | 65 | 14 | 86 | 26 | 105 |
| 2 | PS | F/71 | 33A1 | II | 90 | 21 | 82 | 28 | 105 |
| 3 | PS | M/67 | 33A1 | I | 80 | 17 | 92 | 32 | 120 |
| 4 | PS | M/65 | 33A2 | II | 70 | 12 | 85 | 27 | 95 |
| 5 | CR | F/74 | 33A2 | II | 110 | 15 | 82 | 40 | 105 |
| 6 | PS | F/77 | 33A1 | II | 75 | 14 | 84 | 42 | 95 |
| 7 | PS | M/79 | 33A2 | II | 105 | 12 | 89 | 44 | 100 |
| 8 | PS | M/68 | 33A1 | II | 80 | 9 | 87 | 28 | 110 |
| 9 | CR | M/73 | 33A1 | II | 125 | 23 | 82 | 24 | 105 |
| 10 | PS | F/69 | 33A1 | II | 90 | 14 | 85 | 29 | 110 |
| 11 | PS | F/68 | 33A2 | II | 60 | 15 | 82 | 31 | 100 |
| 12 | PS | M/64 | 33A3 | II | 105 | 16 | 79 | 46 | 90 |
| 13 | PS | M/70 | 33A1 | I | 75 | 14 | 86 | 30 | 90 |
| 14 | PS | F/78 | 33A2 | II | 90 | 18 | 84 | 49 | 105 |
| 15 | PS | M/70 | 33A2 | II | 70 | 19 | 89 | 36 | 105 |
| 16 | PS | F/73 | 33A1 | I | 95 | 22 | 79 | 48 | 110 |
| - | - | 70.8 | - | - | 86.56 | 15.9 | 84.6 | 35 | 103.1 |
| - | - | 64–79 | - | - | 60–125 | 9–23 | 79–92 | 24–49 | 90–120 |

CR, cruciate retaining; F, female; M, male; OTA, orthopedic trauma association; PS, posterior stabilizing; AO/OTA, AO Foundation/ Orthopedic Trauma Association.

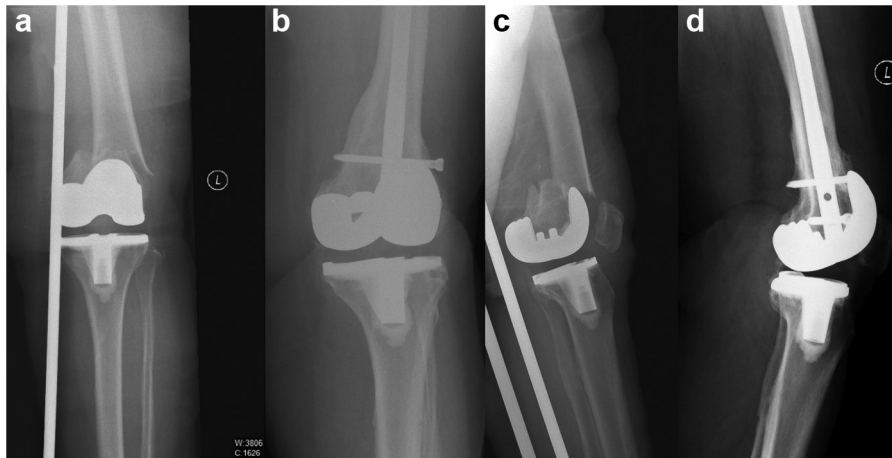


Figure 7. (a, c) Preoperative radiographs showing periprosthetic fracture in AP and lateral views. (b, d) Postoperative radiographs obtained at 1 year postoperatively.

polyethylene post is often examined and exchanged if there is noticeable damage. In the event where an exchange is required, conversion to the conventional technique will be necessary. Furthermore, the resting ligamentous tension of the knee and the size of the tibial post are pertinent to the reduction of the fracture. If reduction is inadequate, exposure of the knee joint and alteration of the ligamentous tension may be necessary. However, in our series, this was not necessary, and the posts were not exchanged. In addition, if the plastic box plug is present, all efforts must be made to remove it. This can avoid the risk of breakage and incarceration leading to third body wear of the implants or become a potential challenge to inserting the nail adequately.

Despite promise, these results are limited by the lack of a comparison group and the single operator with expertise in both arthroplasty and arthroscopy. Thus, surgeons must be well-versed in managing periprosthetic fractures in the event of inadequate arthroscopic visualization and conversion to an open technique being necessary although this was not required in this series. Furthermore, our study took place in a publicly funded health-care setting where no financial costs were incurred by the patient for the use of arthroscopy. Nevertheless, this may not be the case worldwide; thus, the benefit and cost of this procedure must be weighed accordingly in the local setting. In a review of the literature, we found a single case reported by Udagawa et al. utilizing the same technique and reporting similar results [12]. As such, direct clinical comparisons of recovery, rehabilitation, wound infection,

and postoperative pain among multiple practitioners are of future interest in the pursuit of a less invasive approach to managing these fractures.

Conclusions

The outcomes of this series evaluating the technique and safety of the ARIN have demonstrated results comparable with those from previous resources. Although results from this first series suggest that the utilized technique is safe and offers a less invasive approach to fixation of periprosthetic femoral fractures after TKA, direct clinical comparisons in larger scale trials are required.

Conflict of interest

The authors declare there are no conflicts of interest.

For full disclosure statements refer to <https://doi.org/10.1016/j.artd.2022.07.003>.

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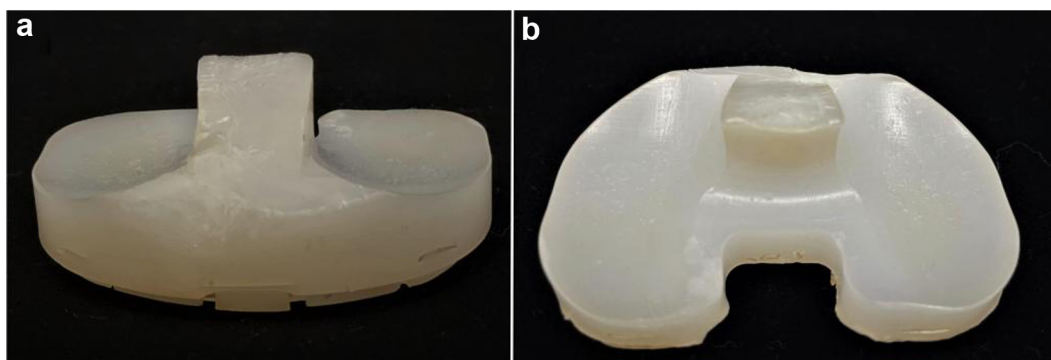


Figure 8. A polyethylene post retrieved from a patient who had undergone retrograde intramedullary nailing for a periprosthetic fracture with the conventional technique and had ended up with a distal femoral replacement for nonunion. (a) Anterior view of the post displaying damage to the post. (b) Posterior view displaying concavity of the post. This patient was not included in the series.

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