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Retrograde entry portal for cephalomedullary nailing in difficult subtrochanteric fractures ☆,☆☆,★

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ABSTRACT

An entry point medial to the tip of the greater trochanter is considered optimal for antegrade femur nailing. The deforming forces in a subtrochanteric fracture often make it difficult to establish a perfect entry point during antegrade cephalomedullary nailing. To overcome this problem, we report a simple technique of making a retrograde entry portal for select difficult subtrochanteric fractures. The technique was used in 12 subtrochanteric fractures. Our indications were morbid obesity, revision nailing and atypical fractures. The technique involves creating a nail entry portal through the fracture from distal to proximal taking advantage of the abducted proximal fragment. Fracture reduction and nail insertion then proceeds in a standard manner. Additional reaming of the thick endosteal lateral cortex through the fracture was performed in atypical fractures. Satisfactory fracture reduction was achieved in all patients and 11 out of the 12 fractures united in the series. 1 patient developed an infected nonunion and was considered failure of treatment. The retrograde entry portal is a valuable alternative method that can be considered in nailing of difficult subtrochanteric fractures to establish an ideal entry point and nail trajectory.

Introduction

The short proximal segment in subtrochanteric fractures is subjected to severe deforming forces by the inserting pelvi-femoral muscles often resulting in flexion, abduction and external rotation [1]. This makes reduction and cephalomedullary nailing of these fractures difficult. To nail such fractures successfully, it is important to start with a proper entry portal after achieving a satisfactory fracture reduction either by closed or open methods. The concept of an ideal entry point for nailing of proximal femur fractures has evolved over a period of time. Though nails with proximal bends allow a more lateral entry to facilitate nail insertion, it has also been shown that it can lead to lateral fracture gapping and unacceptable varus deformity [2]. It can also increase strain and incidence of fissuring at the thin lateral cortex and the possibility of medial cortical impingement [3]. The appropriate entry portal recommended with contemporary nail designs is just medial to the tip of the greater trochanter in the coronal plane [4]. This more medialised entry point has been shown to work best with most of the modern nail designs in terms of clinical outcome [5,6]. In spite of this current knowledge on nailing of subtrochanteric fractures, sometimes it can still be difficult to achieve a perfect entry point and nail trajectory in select patients such as ones who are morbidly obese, patients with atypical fractures and in cases which had been previously nailed [7-9]. To overcome this problem, we report a technique of creating a trans-fracture retrograde entry portal for establishing an ideal start point and nail trajectory in such difficult subtrochanteric fractures.

Indications

The retrograde entry portal technique was used in 12 subtrochanteric fractures in 11 patients (table 1). Institutional review board approval and informed consent were obtained for retrospective use of these patients' data. 5 of them were revision nailing procedures for failed fixations after initial plating or nailing, 3 were bisphosphonate related atypical fractures and 4 were fresh sub-

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Table 1
Patients and summary of results.

	Age/ Sex	Fracture type (initial failed surgeries)	Interventions/Construct with the use of retrograde entry portal technique	Fracture union/ Complications
1	47/M	32A2.1	CM nail (A2FN)	Fracture united at 16 weeks
2	55/F	32A2.1 (failed ABP)	CM Nail (A2FN) - plate construct with bone grafting	Fracture united at 20 weeks
3	62/F	32A3.1	CM nail (PFNA)	Fracture united at 16 weeks
4	33/M	32B2.1 (failed CM nail)	Revision CM nail (PFNA) with bone grafting	Fracture united at 12 weeks
5	44/M	32B3.1	CM nail (A2FN)	Fracture united at 16 weeks
6	49/F	Atypical/ Bilateral	I - CM nail (A2FN) - Bilateral II - Masquelet technique (right)	Left side united at 24 weeks. Right side - nonunion +infection fracture still ununited after Masquelet
7	51/F	32A3.1 (failed ABP)	I - Revision with a CM nail (A2FN) II - Further revision to a CM nail (A2FN) - plate construct & bone grafting	I - No union after 24 weeks II - United 20 weeks after nail-plate fixation
8	30/F	32A3.1 (failed CM nail)	Revision to a CM nail (A2FN)- plate construct with bone grafting	Fracture united at 16 weeks
9	65/F	32C3.1	CM nail (PFNA)	Fracture united at 16 weeks
10	40/M	32B3.1 (failed CM nail)	Revision to a CM nail (A2FN) - plate construct with bone grafting	Fracture united at 16 weeks
11	58/F	Atypical	CM nail (A2FN) - plate construct	Fracture united at 24 weeks

ABP - Angled blade plate
CM - cephalomedullary
A2FN, PFNA (proprietary names, Depuy - Synthes, India)

trochanteric fractures in patients with a body mass index (BMI) of > 35. Fractures were classified according to the AO-OTA system. The indications were chosen based on our prior experience in treating these fractures with cephalomedullary nailing.

Surgical technique

Patient position

Patients were operated in lateral position with provision for fluoroscopy in two planes. The opposite limb was positioned with the hip flexed to facilitate imaging in the lateral plane. The lateral position helps in fracture reduction [10], removal of previously failed implants and easy retrograde guide wire passage and retrieval proximally. The iliac crest was included in the surgical field to allow for bone grafting.

Approach, retrograde guide wire insertion and reduction sequence

A 4-5 cm lateral vastus splitting approach was used to get access to the fracture. A 4 mm drill bit was drilled retrograde through the unreduced fracture parallel to the lateral cortex and made to exit proximally medial to tip of the greater trochanter in the coronal plane and at the junction of anterior 1/3 and posterior 2/3 in the sagittal plane (fig 1). This was followed by passage of the 3.2 mm reversed ball tipped guide wire in the same direction and retrieved through a proximal incision intended for nail insertion. In revision cases requiring an elaborate open approach, the same incision used for fracture reduction was extended proximally for guide wire retrieval and nail insertion. Once the guide wire was retrieved proximally, the proximal fragment was reamed retrograde using the 14 mm proximal flexible end cutting reamer widening the entry portal for insertion of the cephalomedullary nail (A2FN, Depuy - Synthes: India - fig 2). This was followed by fracture reduction and the ball tipped guide wire was manipulated across the fracture into the distal fragment. The distal fragment was reamed in an antegrade manner after fracture reduction. In cases where nails with big proximal diameter were used (PFNA2, Depuy - Synthes: India), additional antegrade reaming was performed using the 16.5 mm entry reamer was performed to create the required space for the wide portion of the nail in the proximal segment.

In fractures that have been previously nailed with a lateralised entry point, we used one or two anteroposterior poller screws in the proximal fragment centred on the previous nail trajectory before creating the new entry point in retrograde fashion. This helped to preserve the new medialised entry point and prevent the nail from falling laterally into the previous track.

In most patients with failed fixations, it was our preference to use a nail-plate construct (see figure, supplemental digital content 1, showing the steps and the final result after nail - plate construct using a retrograde entry portal). In these cases, after retrograde establishment of the entry portal and reaming, fracture was reduced and a lateral 3.5/ 4.5 mm plate positioned posterior to the planned nail trajectory was used to valgise the proximal fragment and load the nonunion site with the help of an articulated tension device (ATD). This was followed by nail insertion and grafting.

Reaming in atypical fractures

In atypical fractures, we preferred reaming of both the proximal and distal fragments through the fracture site in order to preferentially ream the thickened lateral cortices under vision using (6 - 8 mm) sharp end cutting reamers (fig 3). In cases where the medullary canal was found closed, we opened the canal through the fracture site using a 4 mm drill bit under fluoroscopy before using reamers to widen it (fig 4). Once reaming was completed, the chosen nail was inserted antegrade and locked on both sides. If the lateral cortex still deflected the nail medially drifting the proximal fragment into varus, additional steps in the form of a poller screw/ pin placed medial to the nail, further additional reaming of the lateral cortex and or positioning a small lateral plate to securely hold the reduction during nail passage may be required to prevent varus malreduction (fig 5).

Results

The mean age of patients was 48.5 years (30 - 65 years). Patients were followed up for a mean of 17 months (12 - 25 months). One patient was lost to follow up. Fracture reduction was considered satisfactory if the neck - shaft angle was with in 5* of the normal side in the coronal plane without fracture distraction and good bone to bone contact in the sagittal plane without any angular deformity of the proximal fragment. Fractures were considered

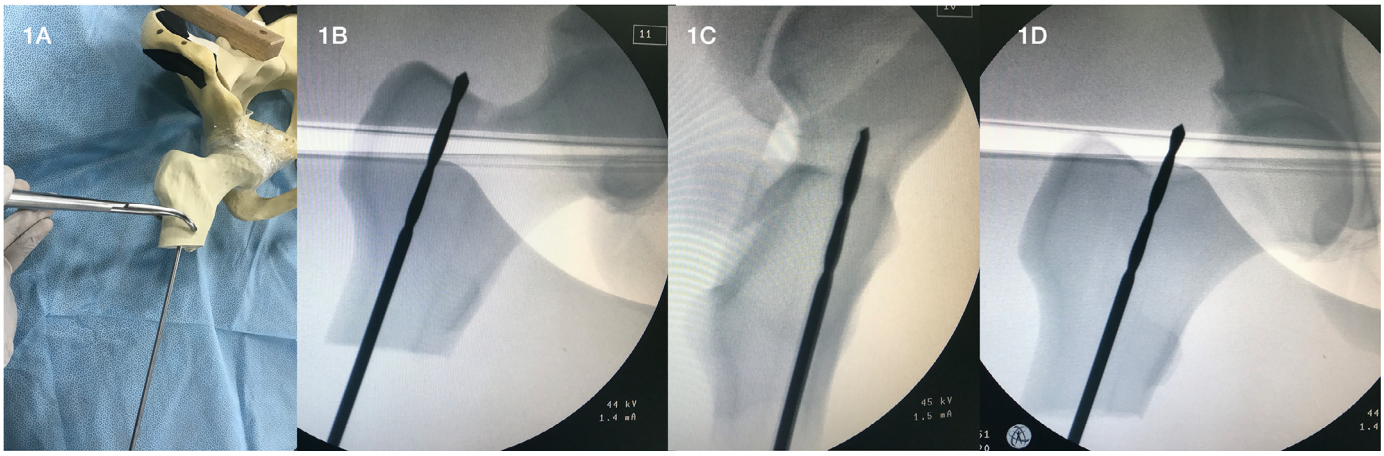

Fig. 1. Technique of making a retrograde entry portal for a subtrochanteric fracture on a saw bone model. With the proximal fragment abducted (1A), the 4 mm drill bit is aimed to exit just medial to the tip of the greater trochanter in the AP plane (1B) and junction of anterior 1/3 and posterior 2/3 in the lateral plane (1C). If a more medial entry point is required as in revisions or atypical fractures, it can still be achieved without much difficulty (1D).

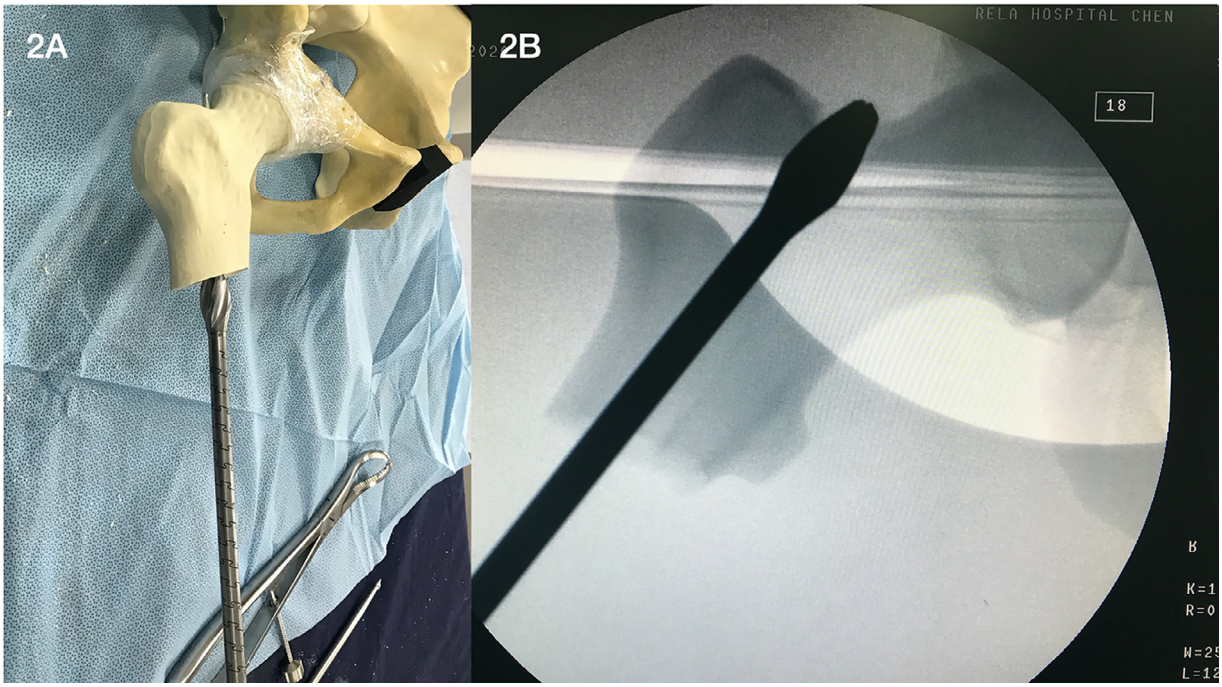

Fig. 2. The entry point is reamed using a 14 mm reamer to establish the nail trajectory parallel to the lateral cortex (2A & B).

united if patients can bear weight independently without pain and bridging callus can be visualised on biplanar radiographs.

The fracture reduction was classified as satisfactory in all patients. No intra-operative complications related to the technique was encountered. Weight bearing as tolerated was allowed in the immediate postoperative period. No loss of reduction was seen. 10 of the 12 fractures in our series had united after the index surgery with in a 6-month period. 1 patient who underwent revision nailing after a failed blade plate fixation failed to unite at 6 months and had to be revised again to a nail plate construct with bone grafting. She ultimately united 5 months after the second revision. 1 patient with bilateral atypical fractures suffered from delayed deep infection on the right side. At 6 months, her left side fracture had united and she was planned to undergo 2-stage Masquelet technique [11]. She underwent debridement, resection of devitalised bone, antibiotic loaded cement spacer and temporary stabilisation with an antibiotic coated locked plate. Her infection was controlled but was lost to follow up before stage II of Masquelet procedure. She did not want to undergo further treatment with us and was considered a failure in terms of assessing results.

Discussion

Starting with an accurate entry point is considered crucial for successful nailing of subtrochanteric fractures. An eccentric entry point can lead to fracture malreduction resulting in varus deformity, instability at the fracture site, limb shortening and can ultimately lead to failure of fixation [12]. Generalisation of an ideal entry point is debatable since it has been shown to vary with patient's proximal femur morphology [13]. The ideal start point as a routine is more medial to the tip of the greater trochanter and it is important to err on the medial side than lateral especially in subtrochanteric fractures to prevent varus [14]. Even a 2-3 mm shift laterally has been shown to gap the fracture significantly and cause malalignment [15]. Streubel et al, showed the ideal entry point was

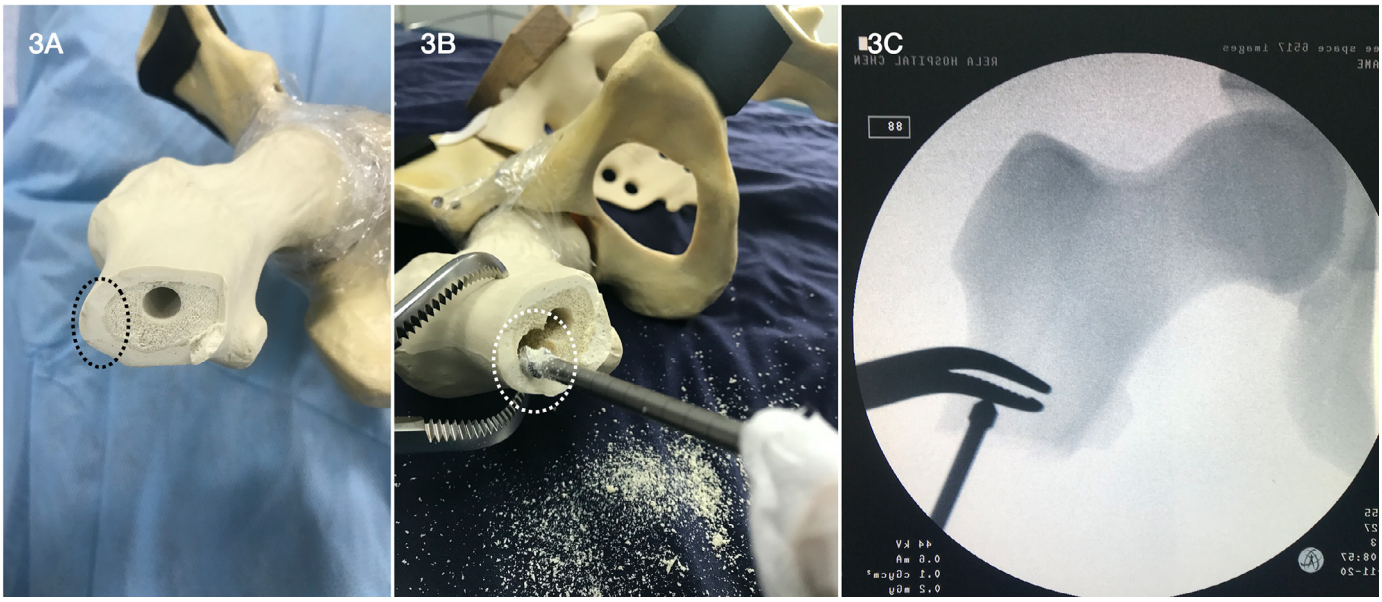

Fig. 3. The thickened lateral cortex (saw bone simulation - black oval) in atypical fractures can be effectively dealt with the retrograde technique (3A). A short solid end cutting reamer provides effective control to trim the lateral cortex (white oval) which is paramount for an appropriate nail trajectory to prevent varus deformity of the proximal femur (3B & C).

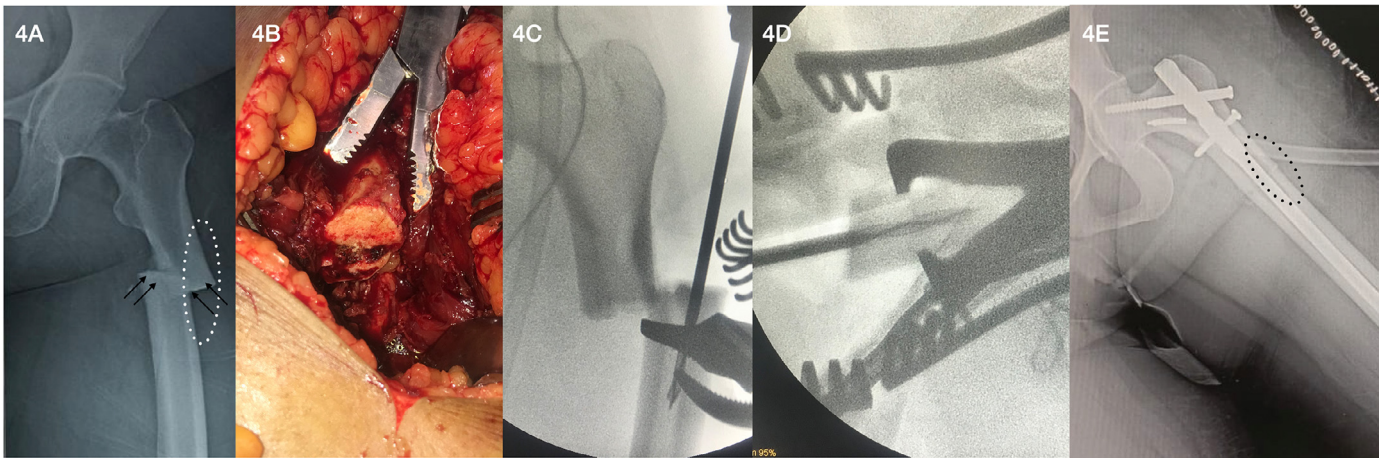

Fig. 4. An atypical fracture with a completely closed medullary canal of the proximal and distal fragments (black arrows) and grossly thickened lateral cortex (white oval 4A). Intra-operative image confirms the completely sealed medullary canal (4B). Retrograde preparation of the entry portal, nail trajectory (4C & D) and trimming of the thickened lateral cortex (black oval - 4E) help achieve anatomical fracture alignment.

at a mean of 3 mm medial to the tip of the greater trochanter using a nail with a 6* mediolateral bend [16]. Both the nails used in our series had a 5* mediolateral bend, hence aiming for a slightly more medial entry point was preferable.

Achieving this more medial entry point in an antegrade fashion is often more difficult in obese patients, previously failed nailing procedures and in atypical fractures due to varus remodelling. Creating the entry point in a retrograde fashion in such situations is easier and more predictable. In retrograde drilling, the drill bit is aimed in a distal - lateral to proximal - medial direction through the fracture and hence it is not restrained by either soft tissues or the bony anatomy. In comparison, drilling antegrade requires drilling in proximal - medial to distal - lateral direction often fighting the gluteal musculature and the flare of the iliac crest (fig 6). Even in lateral position antegrade drilling to achieve a perfect nail trajectory can be difficult in atypical fractures because of their varus morphology and requires excess valgisation of the proximal segment to achieve the correct alignment.

Similarly, retrograde reaming will always ream out the proximal medial bone even in osteoporotic fractures courtesy of the direction of drilling and reaming. This will prevent reamer induced creep of the weak lateral wall allowing the nail track to fall laterally with progressive reaming [17]. Since the proximal fragment is reamed before fracture reduction, the amount of time spent on holding the fracture reduced is much lesser and can minimise the overall time spent on fracture reduction and the entire process of nailing. To avoid the problems with antegrade nailing, DiCicco et al reported on the use of retrograde femoral nailing through the knee in select subtrochanteric fractures. They published satisfactory results in a small subset of patients though the union time was prolonged in a few patients. The technique avoids nail induced fracture site deformation due to antegrade entry point related problems and can be used in some low subtrochanteric fractures [18].

The importance of a more medial entry point is paramount for nailing of bisphosphonate induced atypical fractures. Implanting a trochanteric entry nail through a more medial entry point helps

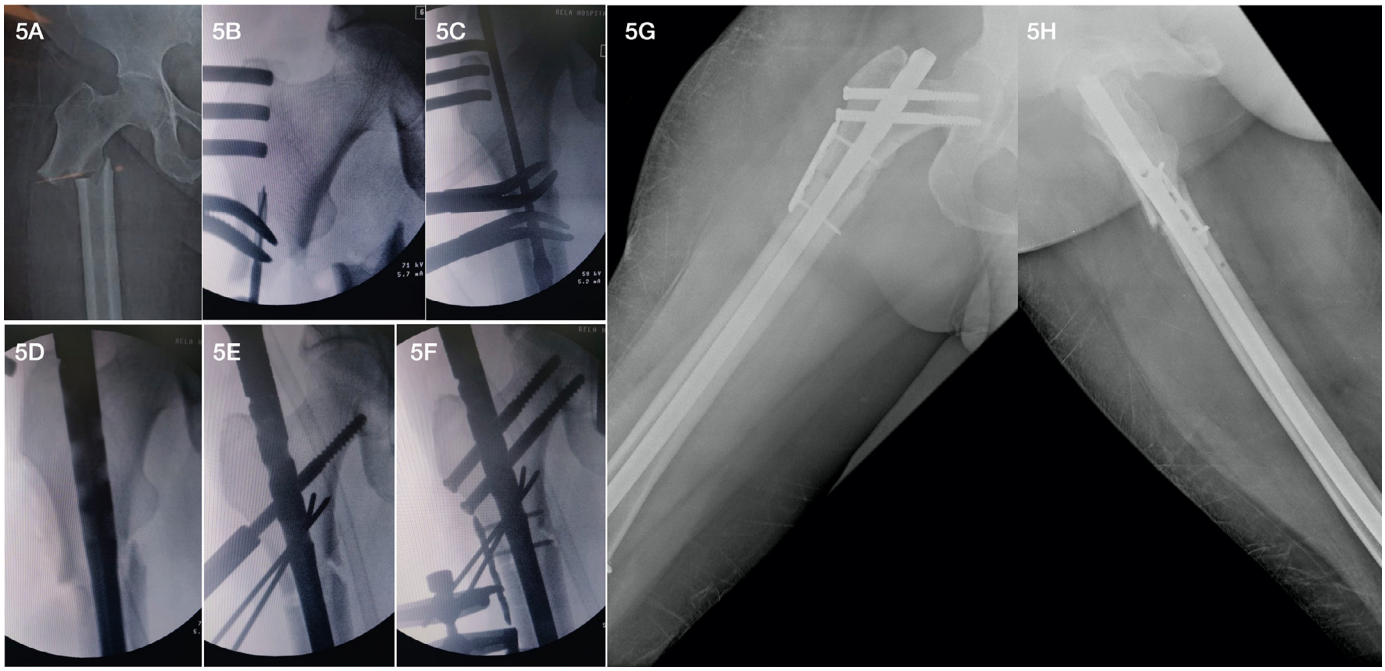

Fig. 5. Atypical fracture in a year-old female (5A). The retrograde entry portal technique (5B) and reaming of the proximal fragment was performed. In spite of a good reduction (5C) the fracture drifted into varus with the nail passage (5D). Further correction was done using medial blocking pins (5E) and further valgised with a lateral plate (5F). Final reduction (5G & H) shows good alignment in both planes.

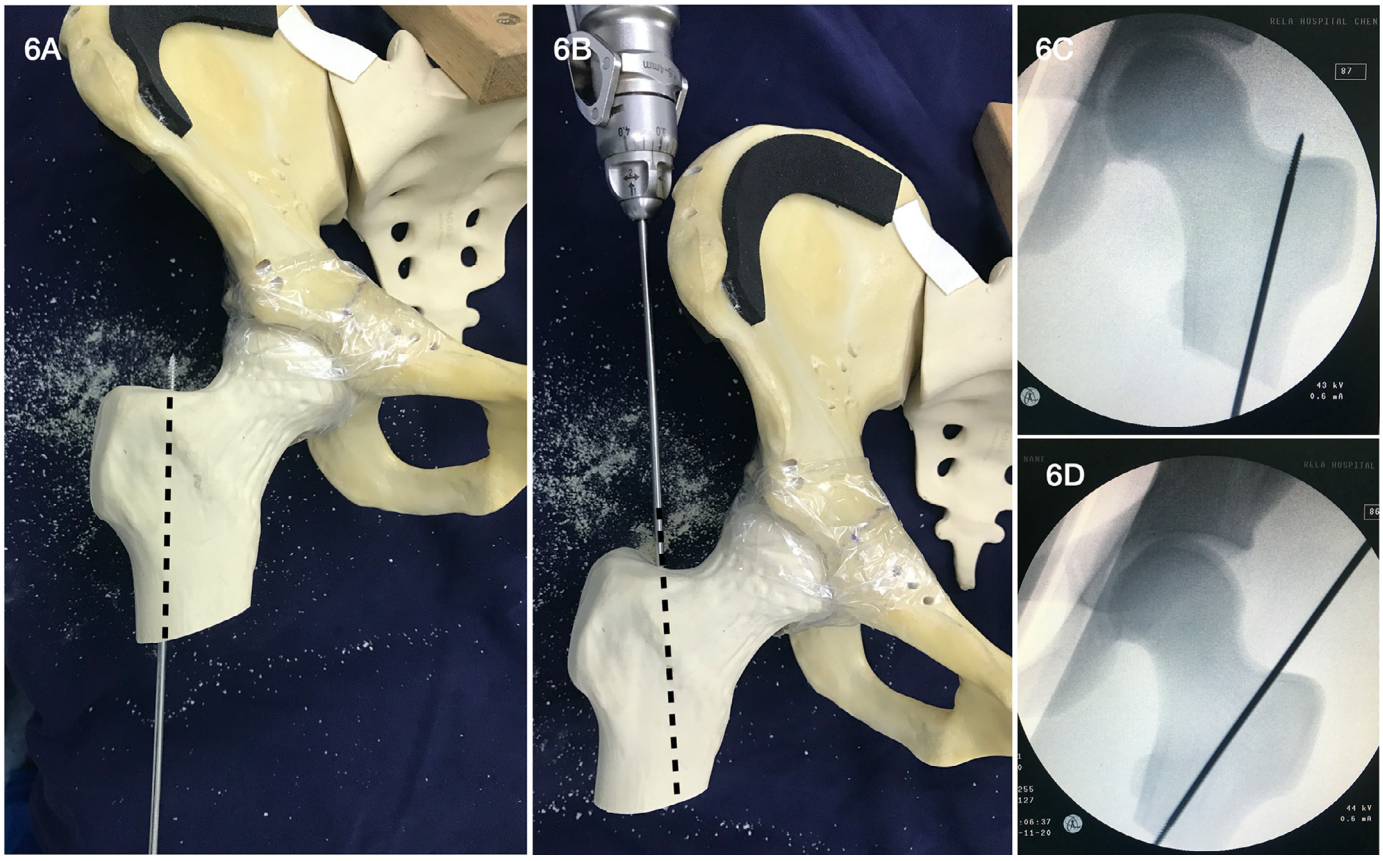

Fig. 6. With the retrograde technique, it is easier to keep the guide pin parallel to the lateral cortex going from (lateral distal to medial proximal) (6A & C) compared to antegrade pin passage (6B & D) using the same entry point. With the antegrade technique, the pelvis often drives the trajectory from (lateral proximal to medial distal) which can predispose the proximal fragment to varus displacement.

achieve valgus of the proximal segment due to mismatch between the nail and the proximal femur geometry [19]. The retrograde technique helps in medialisation of the entry point much more easily than the antegrade technique in such cases. These fractures also have thickened lateral cortex due to variations in bone remodelling. This thickened lateral beak needs to be preferentially reamed in order avoid the reamer taking the path of least resistance medially creating a varus deformity at the fracture. Several techniques have been described to ream the lateral endosteal beak such as excess valgisation of the proximal fragment using an unicortical Schanz pin and lateralisation of the guide wire using a bone hook [20]. While these are valuable techniques, we have found the lateral endosteal beak to be very thick and sclerotic making antegrade focussed reaming with side cutting reamers difficult and incomplete. Our preference is to ream the lateral cortex retrograde through the fracture site under vision using short solid end cutting reamers from the knee arthroscopy set under vision. This offers excellent control of the reaming process making it more reliable, less time consuming and complete in terms of thinning out the lateral endosteal beak. We have also encountered cases with the medullary canal completely sealed off at the fracture site with the remodelled bone making antegrade reaming extremely difficult. Retrograde drilling through the fracture site to create a proper channel for the nail is invaluable in such cases.

The union rate of 83% in the series after the index surgery is lower compared to previously published reports [21,22]. This is predominantly due to the type of fractures included· Only 33% were fresh fractures in normal bone and the rest were either failed fixations or bisphosphonate related atypical fractures. All fresh injuries and 4/5 failed fixations united after the index surgery and 1 failed fracture united after the second revision. So, an open approach did not negatively affect union rates and this has been shown by previous authors too [23].

The main limitations of the study were the small sample size and lack of a comparison group. The study was also retrospective and a single surgeon series. The technique requires an open approach, which if done in a biological manner has not been shown to interfere with bone union or increase wound healing problems. Larger prospective controlled studies can help validate the utility of the technique compared to conventional methods.

Conclusions

The retrograde trans-fracture entry portal is a simple alternate technique for establishing a more medial entry point and an ideal nail trajectory for cephalomedullary nailing in select subtrochanteric fractures. The technique is useful in revision nailing for previously failed fixations, atypical fractures and morbidly obese patients, where there are potential difficulties in accessing the proper entry point or maintaining an ideal nail trajectory.

Declaration of Competing Interest

Authors declare no conflicts in interest

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References

[1] Yoon RS, Donegan DJ, Liporace FA. Reducing subtrochanteric fractures: Tips and Tricks; Do's and Don'ts. J Orthop Trauma 2015;29:S28–33.
[2] Ostrum RF, Marcantonio A, Marburger R. A critical analysis of the eccentric starting point for trochanteric intramedullary femoral nailing. J Orthop Trauma 2005;19(10):681–6.
[3] Linke B, Moein CA, Bosl O, Verhofstad MHJ, Werken CVD, et al. Lateral insertion points in antegrade femoral nailing and their influence on femoral bone strains. J Orthop Trauma 2008;22(10):716–22.
[4] Russell TA, Mir HR, Stoneback J, Cohen J, Downs B. Avoidance of malreduction of proximal femoral shaft fractures with the use of a minimally invasive nail insertion technique (MINIT). J Orthop Trauma 2008;22(6):391–8.
[5] Diab MM, Wu HH, Eliezer E, Haonga B, Morshed S, et al. The impact of antegrade intramedullary nailing start site using the SIGN nail in proximal femoral fractures. A prospective cohort study. Injury 2018;49(2):323–7.
[6] Mallya S, Kamath SU, Annappa R, Nazareth NE, Kamath K, et al. The results of unstable intertrochanteric femur fracture treated with proximal femoral nail antirotation - 2 with respect to different greater trochanteric entry points. Adv Orthop 2020;28:2834816.
[7] Ricci WM, Schwappach J, Tucker M, Coupe K, Brandt A, Sanders R, et al. Trochanteric versus piriformis entry portal for the treatment of femoral shaft fractures. J Orthop Trauma 2006;20(10):663–7.
[8] Bronson WH, Kaye ID, Egol KA. Atypical femur fractures: a review. Curr Osteoporos Rep 2014;12(4):446–53.
[9] Wang SP, Yeo I, So S-Y, Kim K, Moon Y-W, Park Y-S, et al. Atypical femoral shaft fractures in female bisphosphonate users were associated with an increased anterolateral femoral Bow and a thicker lateral cortex: A case-control study. BioMed Res Int 2017;2017:5932496. doi:10.1155/2017/5932496.
[10] Delgado J. Intramedullary Nailing of Subtrochanteric Femur Fractures in the Lateral Position. Tech Orthop 2014;29(3):133–9.
[11] Masquelet A, Kanakaris NK, Obert L, Stafford P, Giannoudis PV. Bone Repair Using the Masquelet Technique. J Bone Joint Surg 2019;101(11):1024–36.
[12] Haidukewych GJ, Berry DJ. Nonunion of fractures of the subtrochanteric region of the femur. Clin Orthop 2004(419):185–8.
[13] Antonelli L. Closed intramedullary nailing of diaphyseal fractures of the femur. Problems related to anatomical variations of the greater trochanter. Ital J Orthop Traumatol 1989;15(1):67–74.
[14] Krappinger D, Wolf B, Dammerer D, Thaler M, Schwendinger P, et al. Risk factors for nonunion after intramedullary nailing of subtrochanteric fractures. Arch Orthop Trauma Surg 2019;139(6):769–77.
[15] Ricci WM, Gallagher B, Haidukewych GJ. Intramedullary nailing of femoral shaft fractures: current concepts. J Am Acad Orthop Surg 2009;17:296–305.
[16] Streubel PN, Wong AHW, Ricci WM, Gardner MJ. Is there a standard trochanteric entry site for nailing of subtrochanteric femur fractures? J Orthop Trauma 2011;25(4):202–7.
[17] Gotfried Y. The lateral trochanteric wall: a key element in the reconstruction of unstable pertrochanteric hip fractures. Clin Orthop 2004(425):82–6.
[18] DiCicco JD 3rd, Jenkins M, Ostrum RF. Retrograde nailing for subtrochanteric femur fractures. Am J Orthop (Belle Mead NJ) 2000;29(9 Suppl):4–8 Sep.
[19] Berkes M, Shaw J, Warner S, Achor T. Medialized trochanteric starting point and focused lateral endosteal beak reaming to optimize success of intramedullary nailing in atypical femur Fractures: A technical trick and case Series. J Orthop Trauma 2019;33(8):e313–17. doi:10.1097/BOT.0000000000001511.
[20] Kasha S, Yalamanchili RK. Management of subtrochanteric fractures by nail osteosynthesis: a review of tips and tricks. Int Orthop 2020;44(4):645–53.
[21] Shukla S, Johnston P, Ahmad MA, Wynn-Jones H, Patel AD, et al. Outcome of traumatic subtrochanteric femoral fractures fixed using cephalo-medullary nails. Injury 2007;38:1286–93. doi:10.1016/j.injury.2007.05.013.
[22] Mingo-Robinet J, Torres-Torres M, Moreno-Barrero M, Alonso JA, García-González S. Minimally invasive clamp-assisted reduction and cephalomedullary nailing without cerclage cables for subtrochanteric femur fractures in the elderly: Surgical technique and results. Injury 2015;46:1036–41. doi:10.1016/j.injury.2015.01.019.
[23] Beingessner DM, Scolaro JA, Orec RJ, Nork SE, Barei DP. Open reduction and intramedullary stabilisation of subtrochanteric fractures: A retrospective study of 56 cases. Injury 2013;44(12):1910–15.