# Pin Locked Kuntscher Intrameduallry Nailing (PLKIN): An Innovative Construct for the fixation of Femoral Shaft Fractures.

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Each author of this article fulfilled ALL 04 Criteria of Authorship:
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## ABSTRACT

**Objective**: To determine the functional and radiological outcome of our newly designed an innovative Pin Locked Kuntscher Intrameduallry Nailing (PLKIN) construct for Femoral Shaft Fractures.

**Methods:** This descriptive study was conducted in Millat Orthopedic and Trauma Surgery Hospital Sargodha- from 23rd February 2019 to 23rd May 2022.All patients with femoral shaft fractures fulfilling the inclusion criteria were treated with our indigenously designed innovative PLKIN construct. The final radiological outcome of PLKIN was determined at two years of follow up by assessing fracture healing. The functional outcome was assessed with Thorensen's criteria and graded as excellent, good fair and poor outcome.

**Results:** We treated 19 patients with PLKIN construct. The mean age was 36.74±3.11 years. Male patients were 13(68.42% ) and females were 6( 31.57%).Right sided femoral fracture was present in 11( 57.89%) patients and left in 8(42.10% ) patients. At two years follow up union was achieved in all 19 patients without additional surgeries. Excellent functional outcome was noted in 14(73.68%) patients and good in 5( 26.31%) patients.

**Conclusion:** Our newly designed innovative Pin Locked Kuntscher Intrameduallry Nailing (PLKIN) construct is an effective device for the treatment of selective femoral shaft fractures as shown by excellent functional and radiological outcome in majority of our patients. We therefore recommend PLKIN construct a suitable alternative to conventional Kuntscher intramedullary nails and interlocking nails for treating femoral shaft fractures.

**Keywords:** Kuntscher nail, Intramedullary nail, Interlocking nail.

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## INTRODUCTION

Femoral shaft fracture is one of the most common fractures accounting for 18.5% of limb fractures and 6% of total bone fractures.[1] Majority of femoral shaft fractures are axially stable fractures.[2] Intramedullary nailing of femoral shaft fractures in adults is a standard procedure in today's trauma and orthopedic surgery.[3,4] Intramedullary nails are broadly categorized as unlocked nails (Kuntscher nail) and locked nails (interlocking nails). Unlocked intramedullary nails (e,g, Kuntscher nail) are although cost effective and technically easy implants but only resist bending forces [5] without opposing the torsional forces.[6] The gold standard treatment of femoral shaft fracture is the is locked intramedullary Nailing.[7] They are locked with screws through nail hole with guiding jig devices and are applicable to different fracture locations.[8,9] Intraoperative fluoroscopy has been an integral part of locked intramedullary nailing to facilitate fracture reduction, nail insertion, and placement of locking transcortical screws.[10] Most interlocking nails are statically interlocked in the index operation but can pose the risk of nonunion and fracture site atrophy because the bone is not under load or stress due to a

phenomenon often referred to as Wolff's law.[11] The transverse cannulations which accommodate the locking screws weaken the interlocking nail and serve as a potential stress concentrator[12] because the area moment of inertia at the screw hole is decreased as compared to the area moment of inertia of the solid portion of the nail. Moreover when interlocking screws are placed proximal and distal to the fracture the fixation becomes load bearing implant which is susceptible to screw or nail bent and break due to cyclic axial, torsional and bending loading.[13] The incidence of breakage of interlocking nail in the femur is approximately 8.2% specially in the distal third of femoral shaft fractures.[14] When the transcortical screws are placed through the interlocking nail the screws do not rigidly interact with the nail and thus do not reduce the stress concentrator effect of the screw holes and the resulting play in the screw-nail interface can result in loss of reduction of the fracture.[15] The accurate placement of the distal locking screws under the fluoroscopic control is a technical issue of femoral interlocking nails yet to be solved [16] as it has a long and tedious learning curve.

Based on the above mentioned difficulties and deficiencies in the conventional interlocking nails and Kuntscher nailing we have designed a construct of pin locked Kuntscher intramedullary nail (PLKIN) device that may work in a slidingly dynamic manner for axially stable femoral shaft fractures to address the above concerns. The PLKIN is our innovative device and can be used for both right and left femurs and without any screw guide devices.

The objective of our study was to determine the functional and radiological outcome of our newly designed Pin Locked Kuntscher Intramedullary Nailing(PLKIN) for Femoral Shaft Fractures.

## METHODS

We conducted this descriptive study in Millat Orthopedic and Trauma Surgery Hospital Sargodha from 23rd February 2019 to 23rd May 2022.All adults patients of both gender with axially stable closed femoral shaft fractures were included in this study. Patients with open fractures, pathological fractures and patients with polytrauma requiring surgical interventions for other fractures or systems were excluded from our study. The study protocols were approved by the Ethical Committee of our hospital. Informed consent was taken from all the study participants. Complete history, physical examination and relevant radiographic and laboratory investigations were obtained in all cases. All fractures were stabilized with our newly designed Pin Locked Kuntscher Intramedullary Nailing (PLKIN).

**The Pin Locked Kuntscher Intramedullary Nailing (PLKIN) Construct.**

In collaboration with local implant manufacturing industry we designed Kuntscher nails of 4.00 to 4.25 mm width (stainless steel 316) with open section longitudinal slit with the obliquity of distal end having length of nail diameter towards the slot and a 5 mm single wall round hole just proximal to it [Fig. I(a)] A flexible wire of 3.5 mm diameter with proximal end having a round hole for 5.00 mm screw and distal end rounded and tapered was also designed and named Amin Pin(Ami-pin) as shown in Fig I(b). A construct of pin and nail is created by engagement of the pre-bent Ami-pin in the hollow of the nail through slot in a slidingly locked manner with pin hole towards the adapted distal end of nail as demonstrated inside the femur bone model suited to the inner cavity [Fig. I(c)] which was inserted in bone model and x-rayed to illustrate the coupling of two component of device [Fig. I (d)] and is referred to as Pin Locked Kuntscher Intramedullary Nailing (PLKIN) construct.

**Figure I (a):** slotted Kuntscher nail. **I (b)** Ami-pin. **I (c):** Coupling of a) and b) resulting in Pin Locked Kuntscher Intramedullary Nailing (PLKIN) construct inside the femur bone model. **I (d):** Radiographic

illustration of PLKIN in-situ.

**Operative Technique**

Preoperatively appropriate length of the nail was measured from the tip of the greater trochanter of the femur to the superior tip of the patella on the uninjured side. All patients were operated under spinal or general anesthesia. All the patients were operated in the supine position with the fractured limb under traction on the fracture table and maximally adducted. For insertion of the PLKIN device a skin incision of 3 to 5cm was made from the tip of the greater trochanter proximally and the soft tissue split to expose the greater trochanter. The medullary canal was opened at the piriform fossa and a ball tipped guide wire was inserted across the reduced fracture. Reaming of the medullary canal of the femur was done and the diameter of the nail was chosen according to the maximal size reamer used. An appropriate nail length was determined by direct measurement of depth of another guide wire insertion. A 3-5cm incision was made over the distal lateral femur and local periosteum was cleared and boundaries of the femur was palpated to precisely place the drill bit in the center of the femur. A 4.5mm hole directed upward, mid-lateral and just proximal to the epiphyseal scar was made. A measured Ami-pin 1cm shorter than the nail length was inserted retrograde through the hole until it passed across the reduced fracture. The Ami-pin can also be inserted antegrade through greater trochanter depending on the level of fracture. The nail was pushed antegrade with the longitudinal slot directed laterally up to lesser trochanter and ball-tipped guidewire extracted out. The nail was pushed further until the nail engaged the pin in the slot [Fig. II (a) and (b)] and passed across the reduced fracture. The ball-tipped insertion guidewire was then reinserted through the nail to the level of the Ami-pin tip engaged in the hollow of the nail. The surgeon clearly felt the metal-on-metal contact of the guidewire colliding with the Ami-pin tip (sounding technique). Any traction was released and manual compression across the fracture site was applied as the nail and pin components of the PLKIN were pushed with alternative hammer strikes until both are *inset* to the desired extent. The distal fragment was shifted either laterally or medially for coronal plane reduction to avoid varus or valgus deformity at fracture site which was also evident by direct inspection of the fracture in open cases. We used a small pad under the fracture site to prevent placement in extension resulting from femoral sagittal alignment in supine cases. Finally locking transverse screws through the pin and nail hole were inserted according to any of the configuration as demonstrated in figure II(c) by blind freehand technique under the guidance of a C-arm machine in AP projection only. No jigs or guide devices were used in PLKIN construct.

All the patients had supervised physical therapy sessions postoperatively. Follow up visits were scheduled monthly for six months and quarterly afterwards till two years. Final evaluation at two years was done radiologically for fracture union and functional outcome was determined with Thorensen's criteria[17] and graded as excellent, good fair and poor outcome.

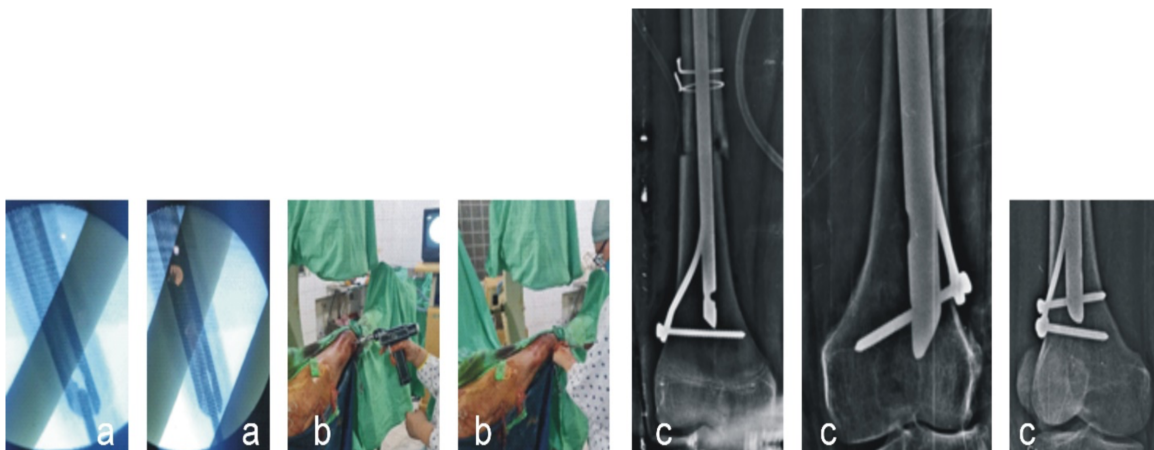


**Figure II (a)** C-arm image intensifier photograph showing engagement of Ami-pin in the nail slot and being advanced proximally. **II (b)** Drilling and insertion of screws in the Ami-pin and distal nail hole by blind freehand technique under C-arm in AP projection. **II (c)** Radiographic illustration of three recommended distal screw configurations without

compromising rotational stability (locking screw through pin hole touching the distal end of the nail, locking screw through pin and distal nail hole simultaneously and locking screw through pin hole and another through nail hole separately.)

We analysed our data with SPSS version 23. Frequency and percentage was calculated for qualitative data. Mean and standard deviation was calculated for quantitative data.

## RESULTS

In this study 19 patients with femoral shaft fractures were treated with PLKIN construct. The mean age was 36.74±3.11 years. Majority(68.42%,n=13) of our patients were male while female patients were 6(31.57%). Right sided femoral fracture was present in 11(57.89%) patients and left in 8(42.10% ) patients. Fracture below the isthmus was noted in 9( 47.36%) patients, at the isthmus in 6(31.57%), above the isthmus in 2(10.52% ) and supracondylar in 2(10.52% ) patients. Mean operative time was 68 ± 24 minutes and mean fluoroscopy time was 2.8±1.1 minutes with AP projection only. All attempts at pin and nail coupling were successful. Distal locking screw through nail hole was passed in the AP projection of image intensifier only and with 100% accuracy with freehand technique. The PLKIN construct was used to fix 9(47.36%) fractures closely and 10(52.62%) with minimal opening of the fracture site. There were minor malalignments of 4 degrees of varus in 2(10.52%) cases and 5 degrees of ante-curvatum in 1(5.26%) cases. The mean follow up period was 30.5±6.1 months (range 25 to 32 months). At two years follow up union was achieved in all 19 patients without additional surgeries. Excellent functional outcome was noted in 14(73.68%) patients and good in 5(26.31%) patients. No major complication was noted in our series.

## DISCUSSION

The concept of Pin Locked Kuntscher Intramedullary Nailing (PLKIN) Construct utilizes the techniques required by different guide devices used in different types of interlocking nails by simplifying it into a single technique without Jig devices and without hazardous radiation exposure in lateral C-arm projection. We used PLKIN Construct for the treatment of axially stable femoral shaft fractures in different locations (Fig. III) and achieved radiological union in all of our patients without additional surgeries. The functional outcome was excellent in 14(73.68%) patients and good in 5(26.31%) patients at two years follow up.The mean operative time in our series was 68 ± 24.Wolinsky[18] reported that the mean operative times was 107 ± 36 minutes for femoral interlocking nailing.Cheung[19] stated that unlocked intramedullary nails act as internal splints with load-sharing characteristics but without rotational control. The PLKIN construct which we have designed from a unlocked nail by slidably coupling of pin through slit in its hollow not only shares the load but also have rotational control for axially stable femoral shaft fractures.

Breakage of the locking screws in conventional femoral interlocking nails are due to bending and torsional forces.[8,14] We had not noted any locking screw breakage in our series. This can be attributed to the fact that the locking screws of our PLKIN construct( one in the pin hole and other in the nail hole) do not bear the burden of torsional forces because these forces are primarily negated by the pin and nail coupled device of the PLKIN and its associated V-shaped construct. Furthermore, the PLKIN device being in dynamic configuration there may not be any stress concentration on the distal screws reducing the chance of screw and nail bend or breakage.

Bong[20] suggested that there are three types of loads acting on an interlocked nail: torsion, compression, and tension. The PLKIN construct with the Ami-pin coupled in the nail however, may enhance torsional strength and minimize tension on nail allowing compression primarily at the fracture ends. Bong also showed that even in the presence of interlocking screws proximal and distal to the fracture site minor movements still occur between the nail and screws and allowing toggling of the bone with loss of fracture reduction. While in case of PLKIN the elastic push of middle segment of the Ami-pin on nail and nail on medial fracture ends cortices may not allow any loss of reduction.

Bucholz[21] pointed out that conventional interlocking nails fail by screw breakage or fracturing of the nail at locking hole sites most commonly at the proximal hole of the distal interlocking screws. The PLKIN construct which we have devised and tested is primarily a dynamic construct and the chances of distal screw and nail failure may be negligible.

Geodgiadis[6] is of the opinion that rotational forces are not opposed by implants when a dynamic interlocking mode is used. Contrary the PLKIN construct primarily negates rotational forces by resisting interfragmentary rotational motion through

three-point fixation, i,e, mechanical lock of pin in the hollow of the nail through nail slot, diverging engagement of pin over the lateral femoral condyle and in the metaphyseal intertrochanteric area through distal and proximal roughly V-shaped constructs configuration. The spring back action of femoral PLKIN construct to restore previous conformation of any rotational deformation during load application may assist in preventing rotational malalignment or deformity of the limb which is not possible with the conventional femoral interlocking nails.

From the above clinical data of PLKIN construct we can assume that this device may provide better stabilization of axially stable femoral shaft fractures by eliminating or reducing the need for a) secondary dynamization by providing fully controlled dynamic compression with physiologic muscle and weight bearing forces and preventing atrophy of fracture ends and enhancing the process of fracture healing.b) distal interlocking screws in lateral fluoroscopic projection decreasing extensive radiation exposure and screw or nail breakage and bending of the conventional femoral interlocking nails. c) all costly conventional femoral interlocking nail implants by combining the biomechanics in one femoral PLKIN construct.

We recognized few limitations of our study. We had a relatively small number of patients and the design of our study was descriptive. Further studies are needed to verify the effectiveness of PLKIN construct.

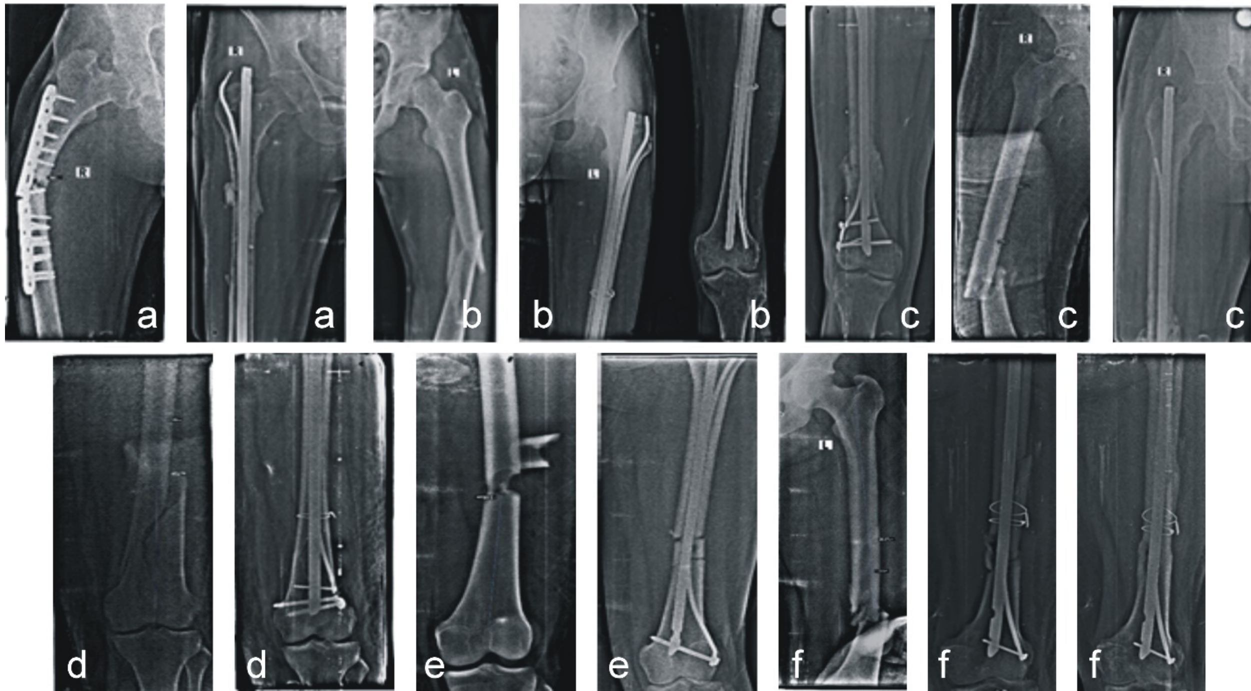


**Fig. III (a)** supra-isthmal femoral shaft fracture with implant failure treated PLKIN construct. Fig. III (b) isthmal comminuted fracture treated with PLKIN construct **Fig. III (c):** infra-isthmal fracture at junction of diaphyseal and supracondylar region treated with PLKIN. **Fig. III (d):** Supracondylar spiral fracture fixed with PLKIN. Oblique. **Fig. III (e)** and **(f):** Distal one third femoral shaft fracture treated with PLKIN.

## CONCLUSION

Our newly designed innovative Pin Locked Kuntscher Intrameduallry Nailing (PLKIN) construct is an effective device for the treatment of selective femoral shaft fractures as shown by excellent functional and radiological outcome in majority of our patients. PLKIN construct is more versatile than conventional interlocking nail for axially stable femoral shaft fractures. It has the advantages of technical simplicity, minimal implant cost, without guides or jig device and minimal image intensifier use for distal locking screws in the AP projection only. PLKIN construct is a promising new concept for rotational stability in the treatment of axially stable femoral shaft fractures. It may prove to be a unique kind of

construct device not available in contemporary market before. PLKIN follows the principle of "sliding intramedullary locking between pin and nail" providing fully controlled primary dynamic compression at fracture site by physiological muscle and weight bearing forces. We therefore recommend PLKIN construct a suitable alternative to conventional Kuntscher intramedullary nails and interlocking nails for treating femoral shaft fractures.

**Conflict of Interest:** None

**Grants/Funding:** None

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