THE INSERTION OF DISTAL FEMORAL INTERLOCKING SCREWS: FREEHAND ANTEROPOSTERIOR VIEW VERSUS LATERAL VIEW TECHNIQUE

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ABSTRACT

Objective: To compare the freehand anteroposterior view technique for the insertion of distal femoral interlocking screws with the lateral view technique in term of success rate, time required and the number of fluoroscopic shots.

Methodology: This Quasi-experimental study was conducted in Orthopedic division Lady Reading Hospital Peshawar from 4th October 2022 to 05th August 2023. In group "A" both the distal locking screws of the interlocking nail femur were inserted under C-arm using freehand anteroposterior view technique while in group "B" conventional freehand lateral view technique was used. The success rate of distal screw insertion was determined using Rohilla and Singh criteria.

Results: The total number of patients were 186.Each group A and B had 93 patients each. No failure of screw insertion was noted in group A while in group B failure was noted for distal screws in 23(24.73%) and for proximal screws in 15(16.12%) patients($p<0.05$). In group A the average time required for the insertion of distal interlocking screw was 6.4±1.3 minutes and 16.9±1.5 minutes in group B($p<0.05$). The average number of C-arm shots were 5.4±1.7 for inserting distal interlocking screws in group A while 15±1.2 shots were used for the insertion of distal interlocking screw in group B($p<0.05$).

Conclusion: We achieved successful insertion of the distal femoral interlocking screws with freehand technique in anteroposterior view in majority of our patients. The technique took less time and less radiation exposure than conventional lateral view technique.

Keywords: C-Arm; Distal Interlocking; Freehand Technique; Fluoroscopy; Intramedullary Nail; Radiation.

INTRODUCTION

Distal interlocking screws play a crucial role in stabilizing the femur shaft fracture by preventing rotation and shortening and thus facilitates the early healing process. The insertion of distal femoral interlocking screws is of paramount importance in orthopedic surgery. Over the years various techniques have been developed to guide the insertion of these screws accurately under C-arm control. Two commonly used techniques are the freehand anteroposterior (AP) view and the lateral view technique. The freehand AP view technique involves the insertion of interlocking screws from the lateral cortex of the distal femur towards the medial cortex under fluoroscopic guidance in antero-posterior view.[1] This technique allows the surgeon to visualize the alignment of the screw relative to the fracture line, ensuring proper engagement and fixation. It provides a direct and straightforward approach to screw placement, but it requires a good understanding of the femoral anatomy and fracture configuration.[2] The lateral view technique involves the insertion of screws from the lateral aspect of the distal femur towards the medial aspect in lateral projection of the C-arm. This technique offers a different perspective by providing a lateral view of the femur, allowing for better visualization of the fracture reduction and screw trajectory.[3] It can be particularly useful in complex fractures or cases where the AP view alone may not provide sufficient information.[4] Both techniques have their advantages and disadvantages. The freehand AP view technique offers simplicity and familiarity, making it a convenient method for many surgeons. It requires no special or additional equipment and can be performed relatively quickly. However, it relies heavily on the surgeon's expertise and may be associated with a higher risk of malalignment if not executed precisely.[5] On the other hand, the lateral view technique provides improve visualization and control over screw trajectory which can lead to more accurate screw placement. It allows for a better assessment of the reduction and ensures that the screw engages the appropriate cortical bone.

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However, it may require fluoroscopic imaging from different angles often necessitating a longer operating time.[6,7]

The standard treatment of lower limb long bone fracture is the intramedullary nailing. Interlocking techniques made it possible to stabilize a wide range of femur shaft fractures.[8] Proximal interlocking can be done with less difficulty using mounted jigs. The most difficult part of the nail is the insertion of the distal interlocking screws.[9,10] The conventional freehand technique for insertion of the distal locking screws is time consuming and exposes the patient, surgeon and his team to a significant level of radiations.[11] Using the anteroposterior view technique the time duration and radiation exposure is significantly reduced.[12,13]

Currently there is no universally acceptable standard freehand technique for the insertion of distal femoral interlocking screws and every trauma surgeon use technique of his own choice based upon his experience and comfort.[14] In this study we aimed to compare the freehand anteroposterior view technique for the insertion of distal femoral interlocking screws with the lateral view technique under image intensifier in term of success rate, time required and the number of fluoroscopic shots. We hypothesized that freehand anteroposterior view technique for the insertion of distal femoral interlocking screws is better than conventional lateral view technique in terms of high success rate, less operative time and less number of C-arm shots.

METHODOLOGY

We conducted this Quasi-experimental study in Orthopedic division Lady Reading Hospital Peshawar Pakistan from 4th October 2022 to 05th August 2023.We included adult patients of both gender and any age with femur shaft fracture requiring interlocking nail and distal screw insertion. Patients with vascular injury requiring vascular intervention, segmental femur fractures, revision interlocking nails and polytrauma patients requiring simultaneous stabilization of other fractures in the same setting were excluded. The study protocols were approved by the Ethical Committee of our hospital. Informed written consent for surgery and publication was taken from all the participants. All patients fulfilling the inclusion criteria were admitted from A & E department of our hospital and stabilized initially as per ATLS protocol. Complete history and physical examination was performed and relevant limb radiographs were taken. The Surgical techniqUe rePorting checklist and standaRds(SUPER) guidelines have been followed for conducting this study and reporting of results.[15]

The anteroposterior view technique(group A) was adopted for every odd patients while lateral view technique(group B) was adopted for every even number patient. All the surgeries were performed by the same team of Orthopaedic surgeons including the primary author or the correspondence author. All the surgeries were performed on traction table in supine position and using C-arm image intensifier (GENORAY, model:ZN-7000,Korea). Spinal or general anaesthesia was used for surgery. Locally made interlocking nails (ESMICO) were used.

A uniform standard technique was adopted for antegrade interlocking femur in all patients. The fracture was reduced closely with traction and manipulation under image intensifier. An entry point was made in pyriformis fossa and a guidewire was passed and crossed the fracture. Serial reaming was done with flexible reamers. An appropriate length and diameter of nail was inserted over the guidewire under image monitoring. The C-arm was positioned above the distal femur in anteroposterior position(group A). After insertion of nail guidewire was retrieved and left in the nail just distal to the tip of the nail. (Fig. IA)An artery clip was used to clamp the guidewire just proximal to the proximal jig(-Fig.IB) for determining a rough estimation of the nail length. The guidewire was pulled up a few centime leaving the distal screw hole vacant and drilling was done with a 5.5 mm drill bit at the proximal femur cortex of the distal interlocking screw.(Fig.IC) The guidewire was advanced forward to strike the drill bit in the nail and conform the accuracy of drill bit inside screw hole of the nail and indicated by increase in outside length of guidewire in the proximal jigs attached with an artery clamp.(Fig.ID). The distal interlocking screw was inserted and again confirmed with guide wire.(Fig.IE) The proximal screw of distal femoral interlocking screw was inserted in AP view under C-arm (Fig.IIA-IID) by repeating the steps of insertion as for distal screw described above.A minimum of two lateral locking screws were placed in both the groups.

In group B(conventional lateral view technique) after insertion of the interlocking nail, the C-arm was rotated and positioned perpendicular to the femur in lateral view in order to get a perfect circular image of the distal screw holes. Using a 4.5 mm drill bit, a hole was drilled aiming the distal locking screw holes. Completion of the holes in both the cortices was confirmed with image intensifier and was followed by insertion of a proper cortical interlocking screw. Screws were confirmed by taking final shot after insertion in lateral and anteroposterior position. We had used the criteria of Rohilla and Singh[16] for categorization of the success of locking screw insertion. According to this criteria the screw insertion was considered "Successful" when only one hole in the lateral cortex was made for single locking screw. The insertion was considered "Successful with Difficulty" when proximal cortex received up to two holes for accurate insertion of a single locking screws. The insertion of locking screw was labelled "Failure" when the lateral femoral cortex received more than two holes for single locking screw insertion.

The time taken for both the distal screw insertion and the number of C-arm shots for insertion in AP and lateral views were recorded. Proximal femoral interlocking was done through jigs and was not included in the study analysis. All the study observations were recorded with the help of a stopwatch by single postgraduate resident who was not part of the study team.

We analyzed our data with SPSS version 29. Frequency and percentages were calculated for categorical variables while mean and standard deviation was calculated for quantitative variables. Time duration, number of image shots and success rate was compared in both the groups and P value was calculated with Chi-square test and independent t-test. P value < 0.05 was considered significant. Data was presented in table where necessary

RESULTS

We operated 186 patients of femur shaft fractures with interlocking nails. Male patients were162(87.09%) and female were 24(12.90%). The mean age was 46±1.3 years.(range 22.4 years to 61 years) Right femur fractures were present in 140(75.26%) and left in 46(24.73%). The femur fracture was located in middle portion in 97(52.15%) patients and distal one third in 89(47.84%). Each group A and B had 93 patients. Majority(65.05%,n=121) of fractures were transverse and oblique followed by comminuted fractures(29.56%,n=55) and spiral(5.37%,n=10) fractures. The diameter of interlocking nail was 11mm in majority(75.80%,n=141) of our patients followed by 10 mm in 35(18.81%) and 12 mm diameter nail in 10(5.37%) patients. Both the distal screw and proximal screw of the distal femoral interlocking screws successfully inserted in majority of our patients in group A as shown in table I. In group B the distal screw of the distal femoral interlocking screws was inserted successfully in 20(21.50%) patients and proximal interlocking screw in 23(24.73%).

Screw insertion failure was not reported in any patient in group A while in group B failure was noted in 23(24.73%) cases for distal screw insertion and in 15(16.12%) cases for proximal screw of the distal interlocking screws insertion. In group A the average time required for the insertion of distal interlocking screw was 6.4±1.3 minutes in group A and 16.9±1.5 minutes in group B(p=0.001) as shown in Table II. The average number of C-arm shots were 5.4±1.7 for inserting distal interlocking screws in group A while 15±1.2 shots were used for the insertion of distal interlocking screw in group B(p=0.02).No significant difference was noted when the success rate of screw insertion, time required and number of C-arm shots were compared with the diameter of nail, gender, type of fracture and side of femur fracture.(p=0.09)

DISCUSSION

The insertion of the distal locking screws is often the most difficult and technically demanding portion of interlocking nailing for femur specially for young and inexperienced Orthopaedic surgeon.[17] Sander[18] has reported 2.6 times greater fluoroscopy time in interlocking nails with free hand distal interlocking screw insertion than without distal interlocking. This can result in maximum radiation exposure in interlocking nail of the femur during the insertion of distal interlocking screws. Various distal targeting jigs or aiming devices for inserting distal locking screws have been designed to reduce the radiation exposure but they are seldom used in routine practice because these devices have been found unstable due to frequent usage.

Furthermore the commonly used interlocking nails often bent or deformed during insertion making these devices inaccurate for pacing distal locking screws.[19] It is also a major concern that obtaining a perfect circular position of the screw holes in lateral C-arm view depends upon the experience and expertise of C-arm operator. Vatkar and Kale[20] have described four difficulties

Table 1: Categorization of the success rate of distal locking screw insertion as determined by Rohilla and Singh criteria.

S. No	Screw insertion Success criteria	Group A(AP view, n=93)		Group B(lateral view, n=93)	
		Distal interlocking Screw	Proximal interlocking screw	Distal interlocking Screw(n=93)	Proximal interlocking screw(n=93)
1.	Successful	82(88.17%)	89(95.69%)	20(21.50%)	23(24.73%)
2.	Successful with difficulty	11(11.82%)	4(4.30%)	50(53.76%)	55(59.13%)
3.	Failure	00	00	23(24.73%)	15(16.12%)

Table 2: Comparison of average time required for distal interlocking screws insertion and number of C-arm shots in both groups.

S. No	Location of Distal femoral interlocking screws	Group A(AP view, n=93)		Group B(lateral view, n=93)	
		Average time required(min)	Average number of C-arm shots	Average time required(min)	Average number of C-arm shots
1.	Distal screw of distal interlocking screws	6.4±1.3	5.4±1.7	16.9±1.5	15±1.2
2.	Proximal screw of distal interlocking screws	3.1±1.1	4.3±1.4	10.9±1.7	11.8±1.0

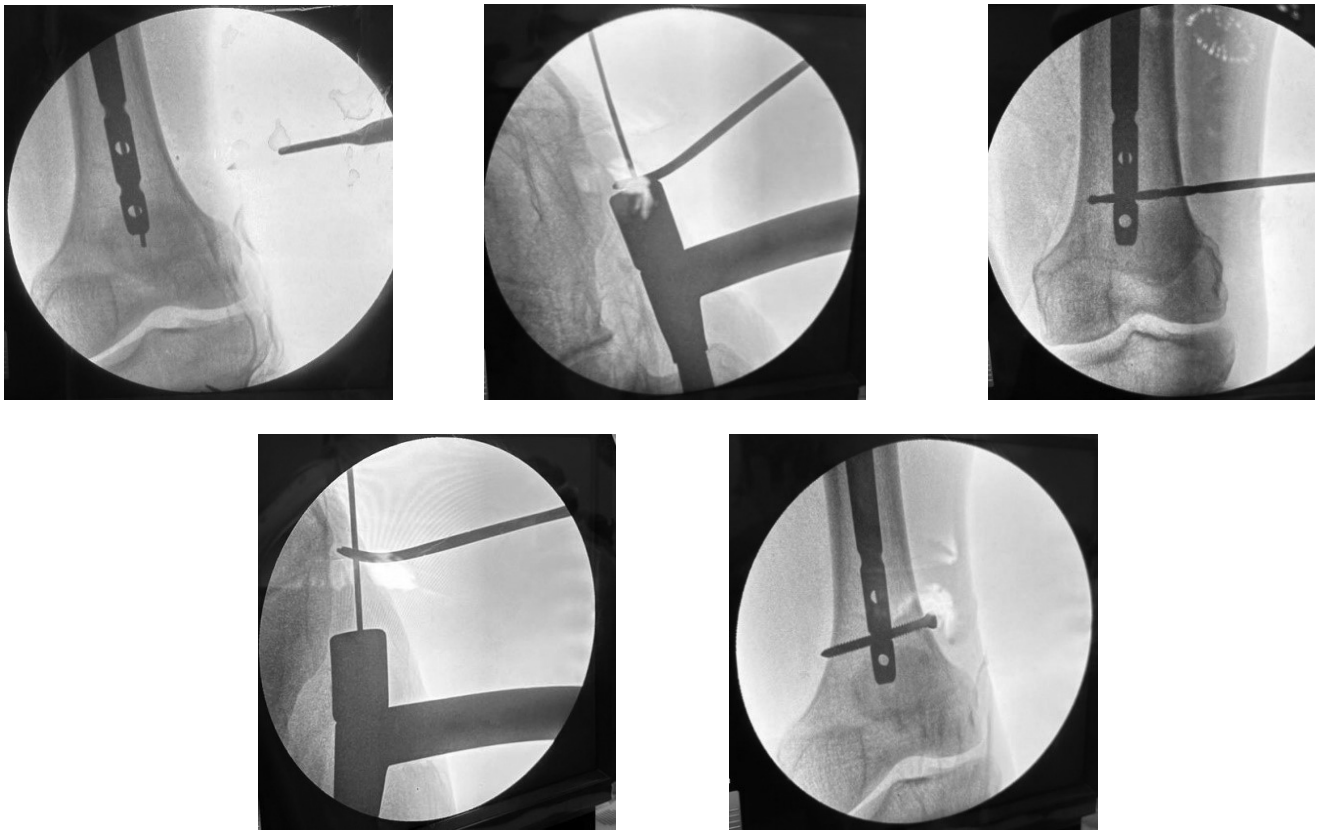

Figure 1A-1E: Steps of insertion of distal interlocking screw in AP view under C-arm image.

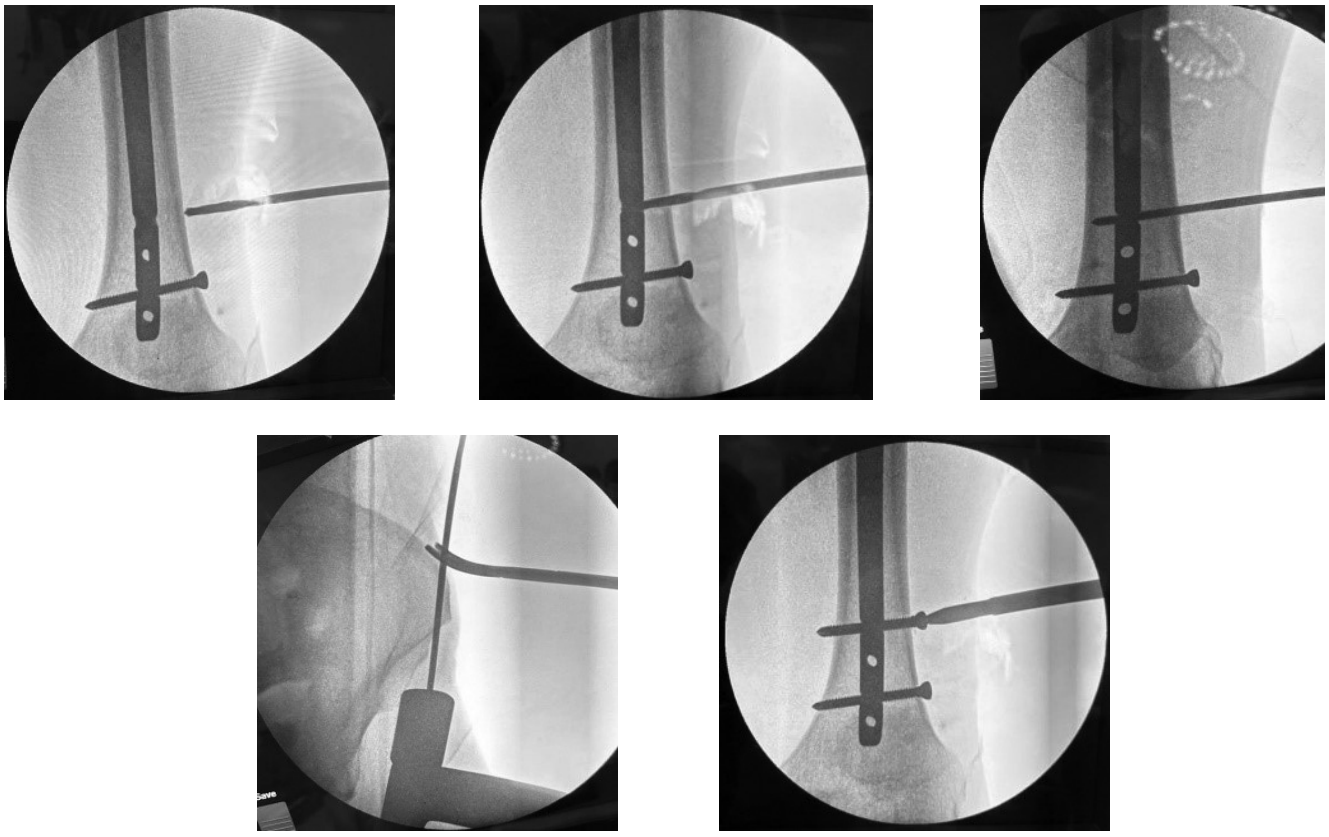

Figure 2A-2E: Steps of insertion of proximal screw of distal femoral interlocking screws in AP view under C-arm.

of distal interlocking screw insertion in lateral view. First, while drilling the lateral cortex there is overlapping of the drill machine and screw hole due to horizontal position of C-arm machine. Second, the drill bit can not be made long enough due to short space available between the C-arm and the patient limb. Third, the operated limb will have to be abducted from standard adducted position to ensure better visualization of screw holes in the lateral view.

Fourth, the frequent changing of C-arm from lateral to anterior view is often required. Insertion of locking screws in anteroposterior C-arm projection has many added advantages. Firstly perfect circular positioning of the distal locking screw hole is not mandatory. Secondly the hands of operating surgeon does not come under direct C-arm radiation beam and drilling can be accomplished successfully without fear of direct radiation hazard. [6]

In our study we had documented that the success rate of distal screw placement, the total time required and the number of fluoroscopic shots were significantly less in anteroposterior technique than in lateral view technique($p < 0.05$).Similar to our study Patra and colleagues[6] inserted distal femoral locking screws in 150 femur fractures in C-arm anterioposterior view and 150 in lateral view. They reported that anterioposterior technique took 4 min(range 3 to 9 min) and consumed 8(range 8 to 18) C-arm shots. The lateral view technique on the other hand took 14 minutes(range 8 to 25 min) and consumed 18(range 10 to 89) C-arm shots.

The surgical time was reduced by 71.4% and fluoroscopic shots were reduced by 55.5% with screw placement in AP view. Chan[21] is of the opinion that the set up time for insertion of distal interlocking screws in lateral view was 105 seconds with an additional 10 seconds time for fluoroscopy shots. According to Chan single distal interlocking screw in lateral C-arm projection took 342 seconds of the total surgical time and 18 seconds of the total fluoroscopy time.

The technique of distal femoral screw insertion in the AP view which we used in our study is not an entirely new technique. Careful literature search however revealed only few relevant studies describing this technique in detail but with different names and modifications.[20,22-24] Vatkar and Kale[20] inserted distal interlocking screws in 27 patients in AP view of c-arm. They reported that the average time required for the insertion of distal screw of the distal interlocking screw was 5.59 minutes and proximal screw 2.7 minutes.

The total number of average C-arm shots used were 11.26.Interestingly these authors named this technique of distal interlocking screw insertion in the AP view as the “TICK TICK Method” because of the reason that when the antegrade guidewire inside the nail is advanced it strikes the drill bit in the screw hole and produce tick tick sound which confirms the accurate position of drill bit in the screw hole of interlocking nail.The design of this study however was retrospective and results are not given in detail. Lal and Vidyarthi[22] performed distal interlocking screw insertion in 834 cases of femoral interlocking nails. These authors have named this technique “Tak-Tak” because of the sound produced due to the collision of advancing guidewire in the nail with the drill bit inside the screw hole and confirming that accurate position of drill bit in the distal interlocking screw.

These authors are of the opinion that this technique is a fool proof technique for distal screw insertion and is 100% accurate. The mean time required for distal femoral interlocking was 11,2 minutes(range 8 to 17 minutes) and radiation time was 5 seconds in their series. These authors however failed to mention the design of study and detailed statistical analysis of their results. Finelli and colleague[23] named the technique of screw insertion in AP view as ”Dip-Stick” technique. They used this technique for distal screw insertion in 212 femur fractures and 603 tibia fractures. The average time for each distal interlocking screw insertion was 3.8 minutes with 7.65 second of radiation exposure.

The technique was successful in all the cases and no lateral view was taken in any case. These authors however reported drill bit breakage(and retrieval) in four of their cases. In our series we have not reported any drill bit breakage. This complication is minor and less frequent and should not nullify the advantages of this technique. Baris[24] called his free hand technique of screw insertion in AP view as “Guide Wire Assisted Locking(GAL)” He compared this technique in 18 cases of femur fractures with 24 in lateral view insertion and 21 cases of tibia with 27 in lateral view insertion. In his cases of distal femoral interlocking screw insertion he noted that the surgical time for GAL technique was 75.48±37.72 minutes while for lateral view technique the surgical time was 93.28±43.62 minutes.

The fluoroscopic time taken for distal femoral screw insertion by GAL technique was 9.33±22.63 seconds and lateral view technique took 42.53±24.55 seconds. This study concluded that GAL technique resulted in statistically significant reduction($p<0.05$) of duration of surgery and fluoroscopic time not only in cases of distal femoral inter locking screw insertion but also in tibia distal interlocking screw insertion. The results of this study are similar to our study with the exception that our sample size was larger and we included only femoral interlocking screw insertion while Baris applied this technique in both tibia and femur interlocking screw insertions.

In our study distal locking screw insertion

was successful in 82(88.17%) and proximal in 89(95.69%) patients. This has important implication because subsequent accurate drilling is difficult because of the offset screw hole as the drill bit used to slip around. This increases the operative time. Moreover drilling two or three holes make the femur weaker and purchase of the final locking screw may be significantly reduced resulting in lessening of the locking screw.[25] Hitting the nail with drill bit can potentially damage the nail and compromise its biomechanical properties.[26]

The conventional lateral view technique of distal locking screw insertion is dependent upon attainment of "Perfect Circle" images of distal locking screws hole under C-arm. It is a difficult and time consuming task and often require continuous use of C-arm shots which is associated with high radiation exposure.[27] It has been reported that Orthopaedic surgeons have 5.37 times more risk of developing cancer due to radiation exposure than general population.[9] Utilizing the C-arm shots up to the minimum necessary level is therefore one of the protective measures to reduce this risk of developing malignancy.

We had documented that the average C-arm shots for anteroposterior distal screw insertion technique was 16.7±1.1which were significantly less than the conventional lateral locking screw insertion technique (24.1±1.9). Gao et al[28] inserted distal femoral interlocking screws in lateral view with free hand technique in 16 patients and noted first success rate in 62.5% with average time consumption of 19.5 minutes. Gao et al has also mentioned few recent alternatives to free hand screw insertion techniques and include Robotic, Electromagnetic, Core drill and Laser Guided Navigation system. These innovative systems may be beneficial but they are costly, technically difficult to operate and not yet available in low income resource countries like Pakistan.

Saket[29] treated 70 patients with free hand lateral view technique and reported time consumption of 22.48±7.62 minutes and number of C-arm shots as 13.5±12.84. Our technique did not require frequent femur manipulation thus avoided weakness of lateral femoral cortex and ensure firm interlocking nail contact with lateral cortex. Other studies also support our results and the usefulness of screw insertion in AP view than in lateral view.[30,31] Recently the Research Institute of AO Davos has introduced a training device by the name of

Digitally Enhanced Hands-on Surgical Training(DEHST) for practicing free hand insertion of distal femoral interlocking screws. This system is composed of mini C-arm machine which generates radiation free simulated virtual images of saw bone and interlocking nail on computer screen. The DEHST has been proved very useful for mastering free hand technique of distal femoral interlocking screw insertion in AP and lateral views.[32]

The limitation of our study were the quasi experimental design of our study, lack of randomization, and inability to measure the actual radiation exposure with dosimeter. The effects of two techniques of screw insertion could not be correlated to fracture healing time and functional outcome because our objective was comparison of the freehand anteroposterior view technique with the lateral view technique in term of success rate, time required and the number of fluoroscopic shots. Nonetheless attention was given to any event which may be related to the technique. Furthermore the usefulness of this technique need to be checked in interlocking screw insertion in distal tibia and distal humerus interlocking nails. Further studies of appropriate designs are therefore recommended to address these limitations and verify our results.

CONCLUSIONS

We achieved successful insertion of the distal femoral interlocking screws with freehand technique in anteroposterior view in majority of our patients. The technique took less time and less radiation exposure than conventional lateral view technique. One can master this technique with practice as it is not technically demanding and does not require any extra training. The learning curve for mastering this technique is not very steep. The technique does not require any special equipment or device. It is reliable and reproducible. The technique is particularly useful for hospitals where C-arm image is of low quality. We therefore recommend insertion of the distal interlocking screws of the interlocking nail femur with freehand technique in anteroposterior view to reduce operative time and radiation exposure.

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Author's Contribution

NU conceived the idea, helped in the literature search, and helped in data analysis and write-up of the manuscript. FAS helped in data collection and analysis. MJI and MAI helped in the data collection and write-up of the manuscript. All authors made substantial intellectual contributions to the study All authors made substantial intellectual contributions to the study.

Conflict of Interest

Authors declared no conflict of interest

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None

Data Sharing Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.