



## Original Research Article

# Comparison of Hip Fixation Nail...its technical and operative advantages over other cephalomedullary nails

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## Abstract

**Aim and Objectives:** To study the technical and operative advantages of Hip Fixation Nail by comparing with other cephalomedullary nails.

**Introduction:** Hip Fixation Nail is one of the simplest cephalomedullary nail for managing trochanteric, peritrochanteric and associated shaft and segmental fractures of femur designed by the author. It has been compared with other cephalomedullary nails for its ease of use, by its design and its extended uses in unstable comminuted trochanteric and peritrochanteric fractures of femur. It scores over all other nails.

**Materials and Methods:** The details of other cephalomedullary nails by its design, instrumentation, operative time, technic, and learning curve, the compression achieved by these nail screw or helical blade in unstable trochanteric fractures, and facility for cement augmentation in osteoporotic elderly bones and augmentation of fixation with trochanteric buttress plate for lateral wall comminution were the points taken into consideration.

**Keywords:** Hip Fixation Nail, TFN, PFN, ZNN, Gamma nail, Halifax nail, Intertan nail, Hip Fracture nail, TFNA, PFNA, PFNA2

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## 1. Introduction

Unstable trochanteric and peritrochanteric fractures are best stabilized with cephalomedullary nails.<sup>1,2,3,4,5,6</sup> There are number of cephalomedullary nails to manage trochanteric fracture of femur. They come in Two screw system or one screw/blade system. The examples of two screw system are Trochanteric Fixation Nail (TFN), Proximal Femoral Nail (PFN), Intertan nails whereas examples of single screw / blade system are Gamma nail, Halifax nail, Zimmer Natural nail, Stryker Trausons Hip Fracture Nail, Proximal Femoral Nail Antirotation (PFNA) and Proximal Femoral Nail Antirotation for Asian population (PFNA2). Trochanteric Fixation Nail Advanced (TFNA). The details of each of above mentioned nails...its design, how the compression is achieved, whether the compression achieved is maintained or lost to some extent, whether augmentation of fixation is possible or not and its cost and simplicity or complexity of learning curve is described in discussion.

Author has designed this Hip Fixation Nail in 2020 and published his results in initial 43 cases in Indian Journal

of Orthopaedics surgery (IJOS) publication September 2022.<sup>7</sup> A multicentric prospective analysis of 189 cases of trochanteric and proximal femur fractures fixed with Hip Fixation Nail with a follow up of one year and more was studied.<sup>8</sup> The description of Hip Fixation Nail is shown in **Figure 1A** and **Figure 1B**. The short nail is available in 18 cms length with proximal end of 15 mm diameter and mediolateral angle of 5°, and comes in 130 and 135° angles. The long HFN is side specific nail and is available from 34 to 42 cms long and in 9mm to 12mm diameter which is useful in trochanteric fractures associated with shaft and segmental fractures of femur **Figure 1C**. The cervical screw has a head and is 10 mm in diameter and has four trenches on its shank for locking anti rotation screw. It has tapered tip and has four holes at 90° in threaded portion for cement augmentation. There is antirotation screw at proximal end of nail which locks the cervical screw preventing rotation and allows sliding if required. Hip Fixation Nail can be locked distally in static or dynamic mode.

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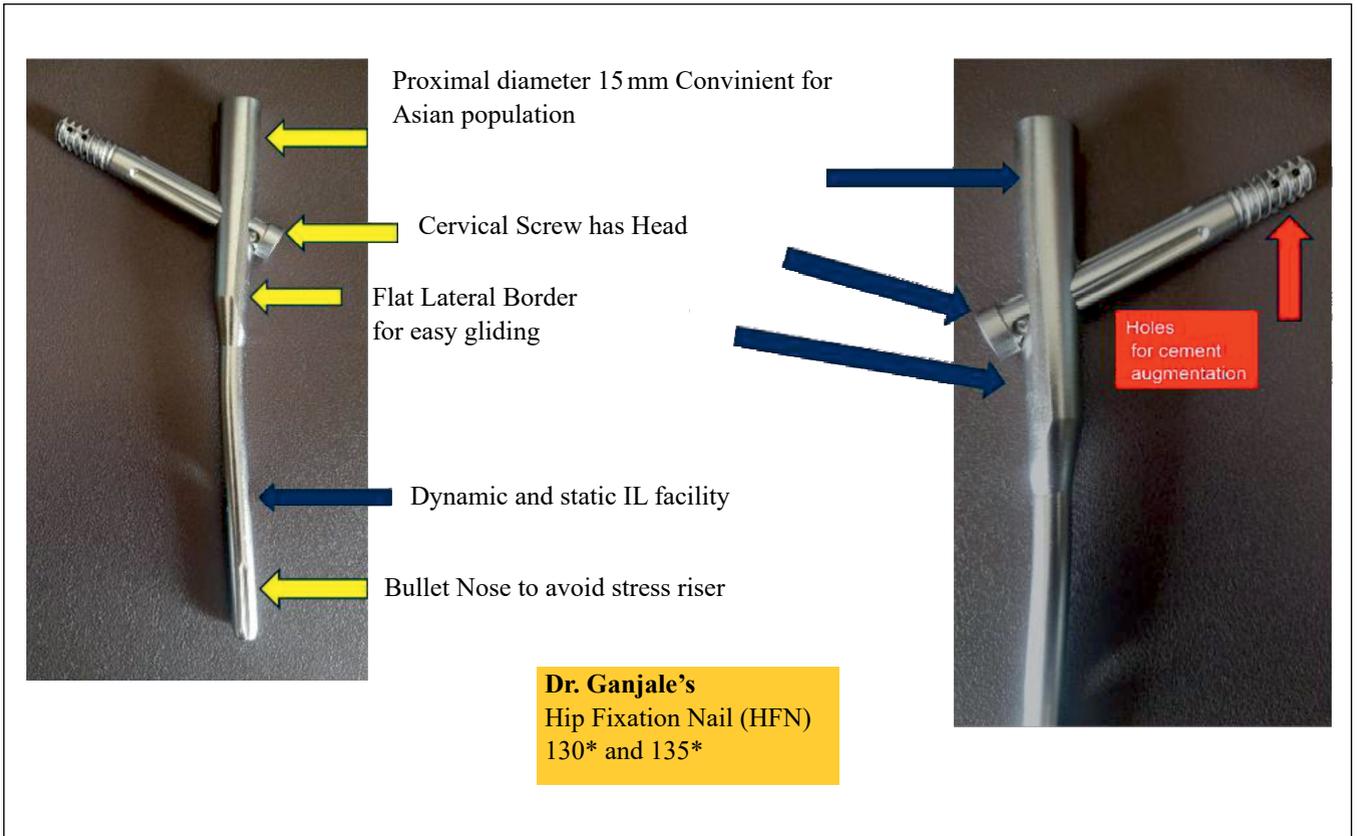


Figure 1A: Hip Fixation Nail design

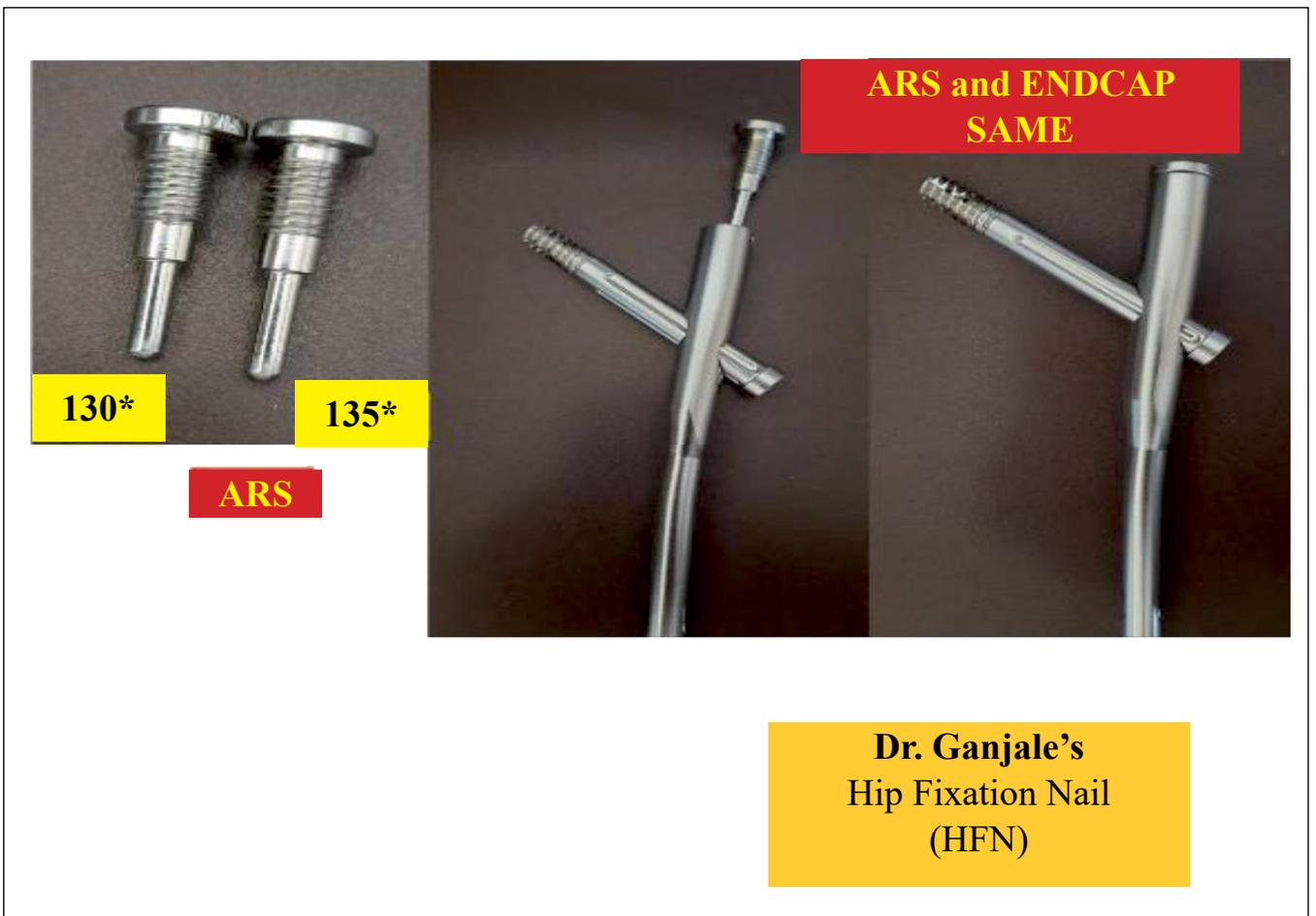


Figure 1B: Short Hip Fixation Nail (Length 18 cms)

## Long Hip Fixation Nail

Side specific Right and Left sided

Matches Anatomically with Femoral Shaft bow

Useful in IT and associated Sub trochanteric Shaft fractures and Segmental fractures

Available in sizes from 9 mm to 12 mm diameter and 34 to 42 cms length.



**Figure 1C:** Long Hip Fixation Nail (Length 32 to 42 cms) for trochanteric fractures associated with shaft fractures and segmental fracture shaft of femur.

## 2. Discussion

The discussion is based on following points with each of the nails

1. Screw heads
2. Limitation of Compression
3. Compression achieved is lost to some extent after jig removal
4. Augmentation with Trochanteric buttress plate
5. Augmentation with bone cement or bone substitute in elderly osteoporotic bones
6. Nail designs
7. Removal of bone stock in neck of femur (Neck Occupancy of screw /blade)

### 2.1. Screw head

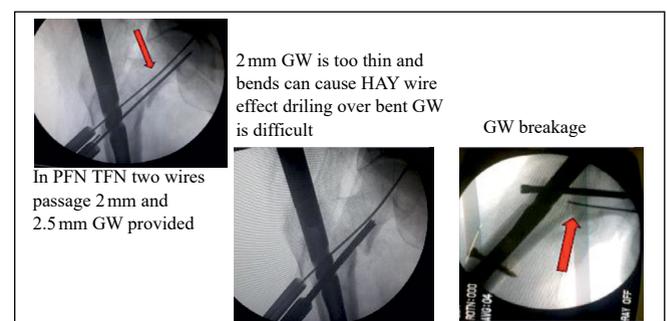
Screw head plays important role in achieving compression and maintaining it independently and irrespective of jig or compressive devices, If the screw has no head there are chances of screw penetration through and through into head neck or migration of screw inside which is a dreaded complication and is difficult to retrieve it back. **(Figure 2)** Many of the implants available in market have headless screws. These headless screws have no hold on lateral wall and can toggle and loosen up in due course of time, more so in comminuted and osteoporotic bones.



**Figure 2:** Penetration of headless screw being headless blade trochanteric buttress plate cannot be applied for lateral wall comminution to augment the fixation

PFN and TFN two screw system are most commonly used implant to manage stable as well as unstable trochanteric fractures.<sup>9</sup> The original Synthes PFN is two screw system but it has headless screws. The Indian version of TFN PFN has screw heads to rest over lateral wall of trochanter to have good bony purchase and maintain the compression achieved, acts as a buttress for lateral wall too, In comminuted lateral wall fractures, the screw can be tightened till the screw heads rests over nail and nail itself will act as a lateral wall. The author has designed Trochanteric buttress plate for TFN and PFN in 2015 in case of comminuted lateral wall and is been used since then to augment the fixation because the PFN TFN screw heads get tightened over Trochanteric buttress plate and augments the fixation.<sup>10</sup> The lateral wall comminution can be overcome only if screw has a head. There are other methods also to augment lateral wall like putting cannulated cancellous screw transversely into Greater trochanter, encircilage wiring of greater trochanter lesser trochanter and shaft etc. comminution depending on fracture geometry and quality of bone and bone stock.

To put two screws of TFN PFN we should put two guide wires into neck and head. the guide wires are thin and can bend while drilling in and cause hay wire effect, further more drilling over bent guide wire can break the guide wire and is difficult to retrieve them or may end up in putting only one screw leading to unstable fixation. **(Figure 3)**



**Figure 3:** Hay wire effect of thin guide wire and breakage

Technically putting two screws of TFN PFN and to accommodate them in narrow neck of femur in Asian short stature patients is difficult.<sup>11,12,13,14</sup> This can be overcome by using single screw/blade system in such type of patient. There will be lot of space to err the placement of single screw and accommodate in the neck. So Hip Fixation Nail is ideal implant in such case as the screw has a head. Trochanteric buttress plate is also available for Hip Fixation Nail in case of lateral wall comminution fractures to augment the fixation.

### 12.1.1. PFNA and PFNA2

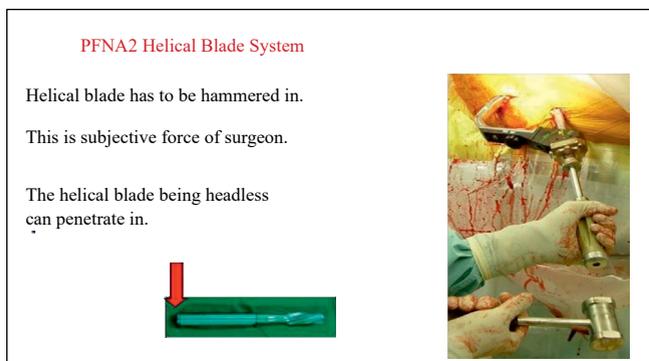
This device allows for improved purchase in the femoral head by radial compaction of the cancellous bone around the blade during insertion. Fixation stability, antirotation, and anti-varus collapse are some of the noted advantages of helical neck blade.

### 12.1.2. Worrying issues of PFNA

Initial versions of PFNA, there was no set screw to lock the blade in compression so chances of cervical screw blade migration was more. Mandatory compression can loosen the blade. Proximal end of PFNA is larger in diameter so removes large volume of bone. There is no inbuilt design for cement augmentation in osteoporotic bones

1. PFNA2 came with Refined design
2. Proximal Femur Nail Antirotation for Asian population
3. Proximal diameter was made 15 mm
4. Mediolateral agulation was reduced to 6\*
5. The lateral surface of proximal end of nail was made flat for easy gliding
6. Mandatory compression (of 5 mm) was dictated by implant company
7. Locking the blade by set screw was added to maintain compression of blade.

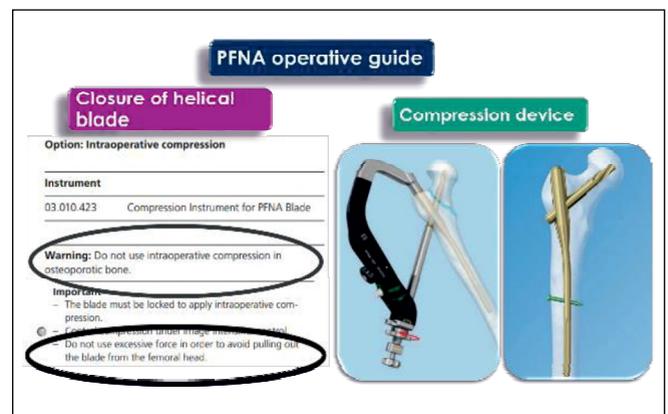
PFNA2 blade has to be hammered in which is subjective force varying with surgeon and in attempt of exchanging for correct sized blade can loosen the blade purchase in bone (Fig 4) Migration of the helical blade leading to perforation into the hip joint without loss of reduction was found in one of our cases done with PFNA II, 3 months after surgery.. So a screw system is better than blade, we can always gently screw in the cervical screw..<sup>3,7,8,15,16,17,18</sup>



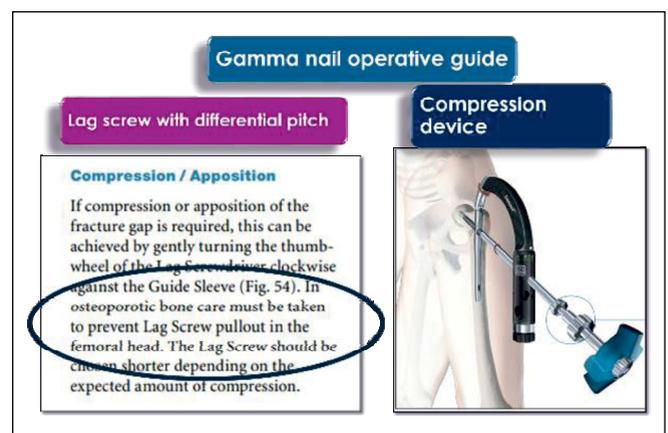
**Figure 4:** Hammering of PFNA2 helical blade is subjective force

### 2.2. Limitation of compression

Different implants dictate different amount of compression of cervical screw or blade. Like 5 mm 10 mm 15 mm fixed compression. They have mentioned in their operating guide, **Figure 5 and Figure 6** not to over pull the blade against sleeve TFNA2 or over compress the screw Gamma nail screw... The question is if we want in between grade of compression in a given case say 7 mm, we cannot give so the fixation is unstable, if we want 12 mm we cannot achieve that compression as implant company has limited the compression to 10 mm only. So in either case the fixation is not rigid and is unstable. So in any given case a surgeon should be able to achieve a good optimal compression in that given case. Hip Fixation Nail designed by author and Indian version of TFN and PFN can give unlimited compression as per case irrespective of compression device or jig sleeves, against which the compression is achieved. This is biggest advantage and freedom to a surgeon to achieve optimum compression.



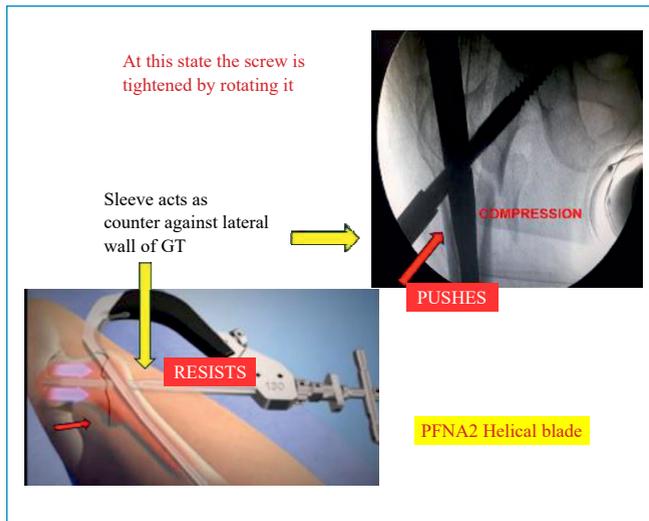
**Figure 5:** Operative guide for PFNA



**Figure 6:** Operative guide of gamma nail

2.3. Compression achieved is lost to some extent after jig removal.

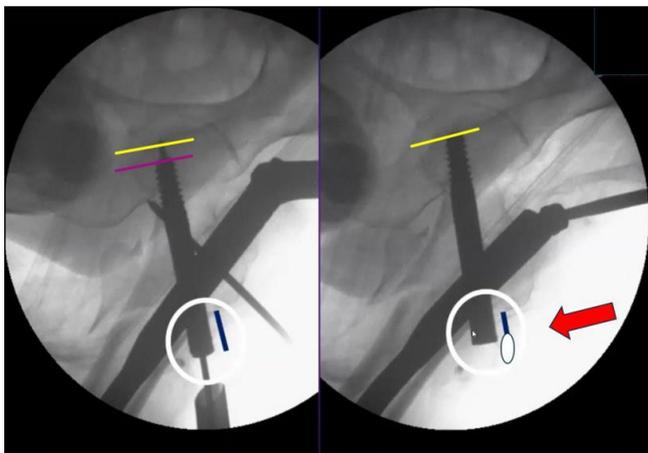
Let us know how the compression is achieved in Hip Fracture nail PFNA PFNA2 Gamma Nail in which screw or blade is headless. These systems come with complex jig nail assembly with aiming and compression devices and sleeves. These sleeves act as resistance to pull over the helical blade over the jig. (**Figure 7**)



**Figure 7:** Showing how compression is achieved in Gamma nail and Hip fracture nail of Strausons by sleeve pushing lateral wall and PFNA2 the sleeve is resisting the pull of helical blade

In certain nails the sleeve pushes the lateral wall to achieve compression of screw. The compression achieved is lost to some extent as and when the jig is disassembled from nail, In certain nails inspite of set screw locking the cervical screw the compression is lost because the cervical screw has no head thus lateral wall displaces laterally loosing the compression. If the cervical screw has head it acts as door stopper mechanism to avoid lateral displacement of lateral wall of greater trochanter.

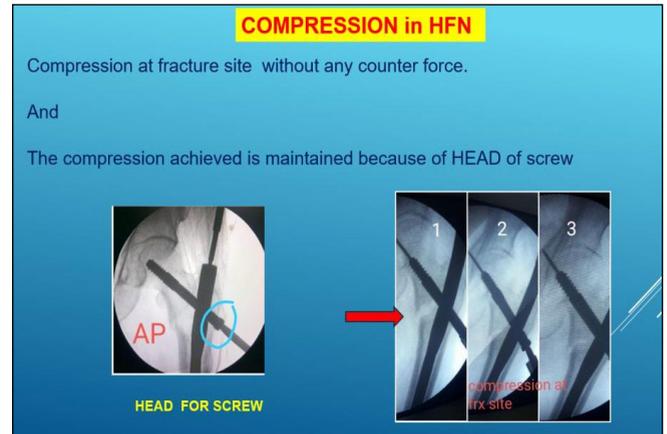
The PFNA and PFNA2 operative guide also warns not to use excessive force in order not to pull out the blade from femoral head. Similarly Operative guide for Gamma nail also clearly mentions that in osteoporotic bone care must be taken to prevent pull out of lag screw from the femoral head. **(Figure 8)**



**Figure 8:** Head less screw or Helical blade allowing lateral displacement of trochanter after jig removal and the compression is lost

The head of Hip Fixation screw acts as a buttress against lateral wall to maintain compression achieved. The Hip

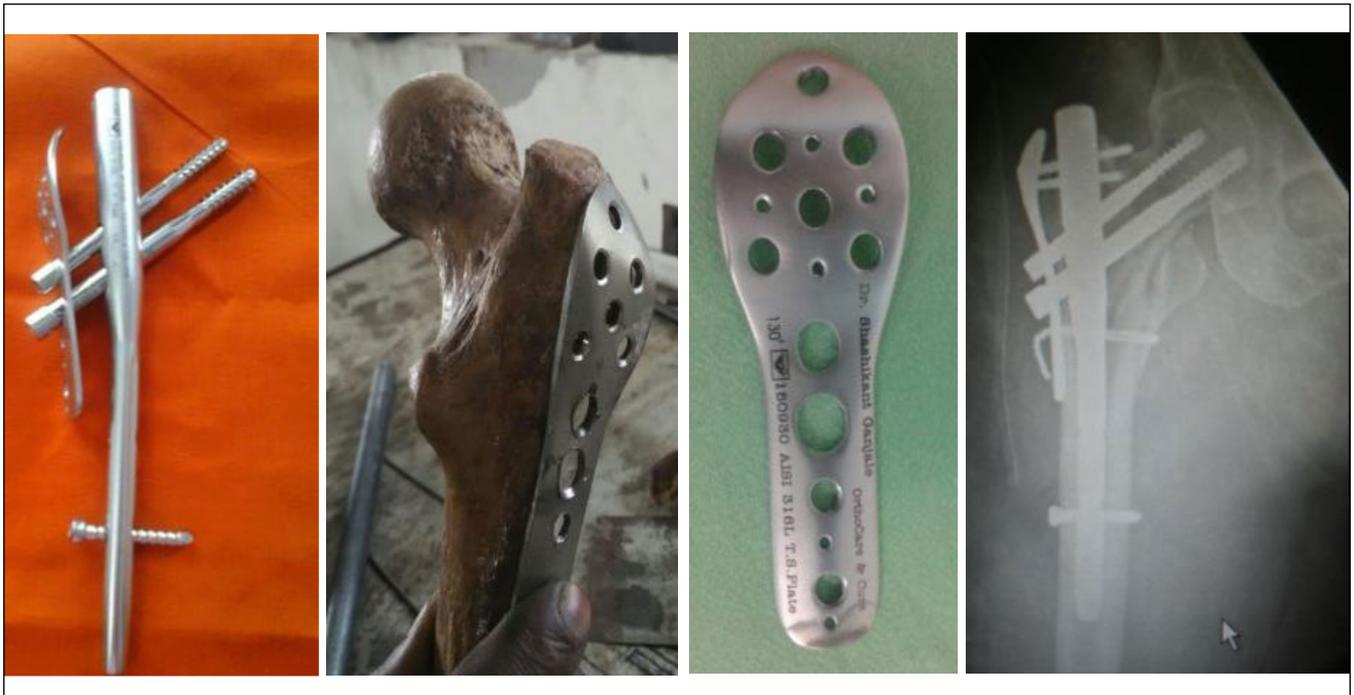
Fixation screw has a head so it abuts against lateral wall and buttresses it to maintain the compression achieved independent of sleeve or compression device. **(Figure 9)**



**Figure 9:** Hip Fixation Screw has head achieves compression irrespective of any device or sleeve The head of screw rests on lateral wall and maintains the compression achieved

#### 2.4. Augmentation with trochanteric buttress plate

The author has designed trochanteric buttress plate for Indian version of PFN and TFN in 2015 and is being widely and routinely by many of our orthopaedic colleagues with excellent results.<sup>10</sup> **(Figure 10)** So also the author has designed trochanteric buttress plate for Hip Fixation Nail. **(Figure 11)** Hip Fixation Nail designed by author and Indian version of PFN TFN have screws with head that abuts against trochanteric buttress plate augmenting the fixation. None of the single screw or blade system available in market has head. All are headless screw or helical blade. So the major disadvantage is augmentation of fixation in unstable and lateral wall comminution fractures is not possible.<sup>7</sup> Trochanteric buttress plate cannot be augmented in conjunction with PFNA PFNA2 Gamma nail ZNN nail Halifax Nail Hip fracture nail or TFNA advanced. In case if trochanteric buttress plate is not available the screw can be fully tightened over nail and screw head touching nail, such that nail will act as lateral wall. This advantage is not available in headless screws /blade .and they can penetrate into head neck. Even AO Sys trochanteric support plate allows the screw heads of TFN PFN to pass through its hole. It has additional holes to anchor screws in big bony chunk of greater trochanter (lateral wall) depending on bone stock and bony comminution. The screws may not have bony purchase in comminuted part making weak augmentation and back out in due course of time. The Trochanteric buttress plate designed by the author for TFN, PFN or Hip Fixation Nail has holes for cervical screws which pass through the respective holes and heads of screws can be tightened over the trochanteric buttress plate making nail plate and bone a single assembly reinforcing the fixation.



**Figure 10:** Trochanteric buttress plate for TFN PFN having screw heads

## Trochanteric Buttress Plate for Hip Fixation Nail



**Figure 11:** Trochanteric buttress plate for Hip Fixation Nail

### 2.5. Augmentation with bone cement or genex paste bone substitute in elderly osteoporotic bones

Hip Fixation Nail designed by author has a facility for cement augmented fixation. The cervical screw has four holes at 90 degrees in the threaded portion. **(Figure 12)** The liquid cement when injected through cannulated cervical screw leaks out of holes by the side and at tip and spreads around the screw tip.

This is useful in elderly osteoporotic bones. The liquid cement is injected through the cannula or tubing into predrilled holes made for cervical screw and some amount of cement is applied to threaded portion of screw tip and is screwed in place through proper sleeve and tightened before cement sets in **Figure 13** and **Figure 14**.

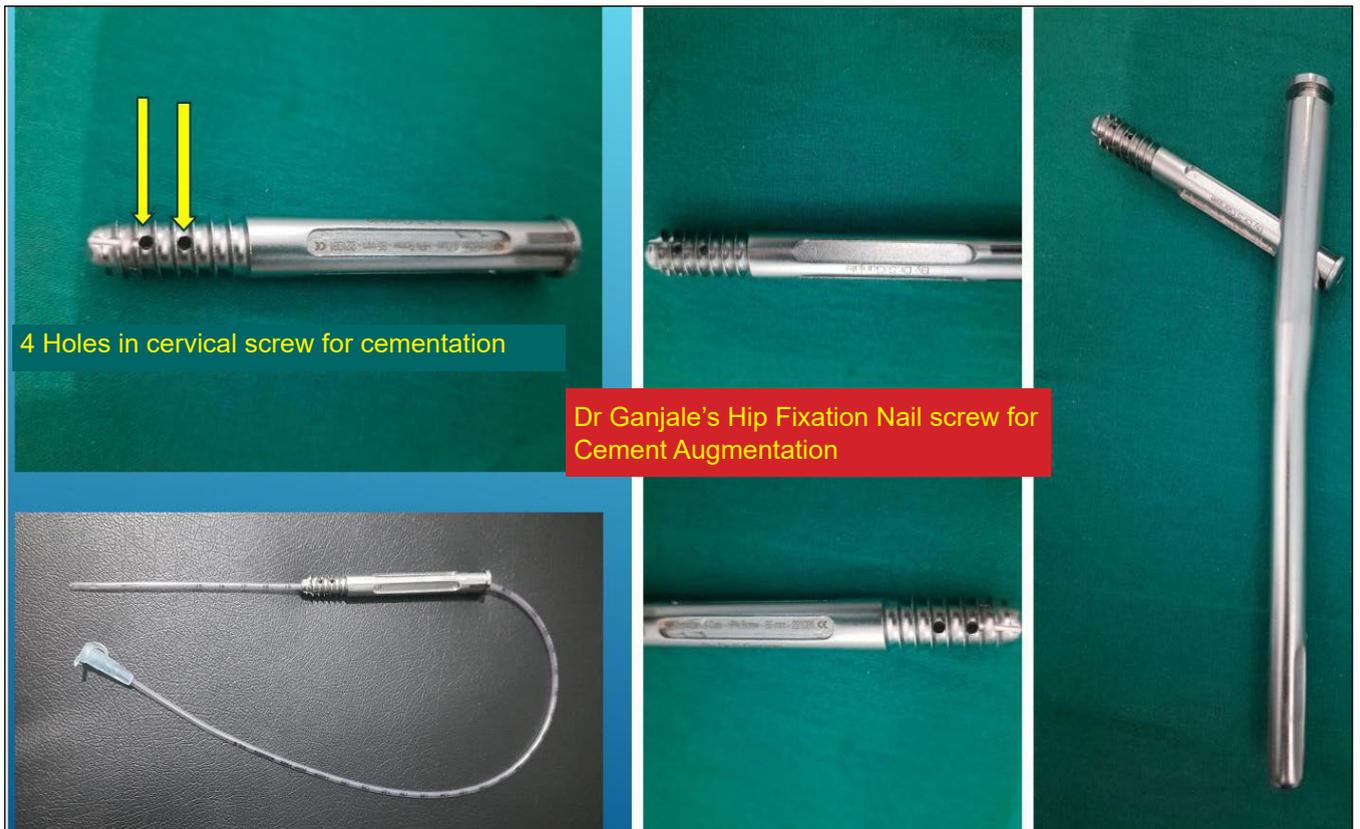


Figure 12: Hip fixation screw has holes in threaded portion for cement augmentation

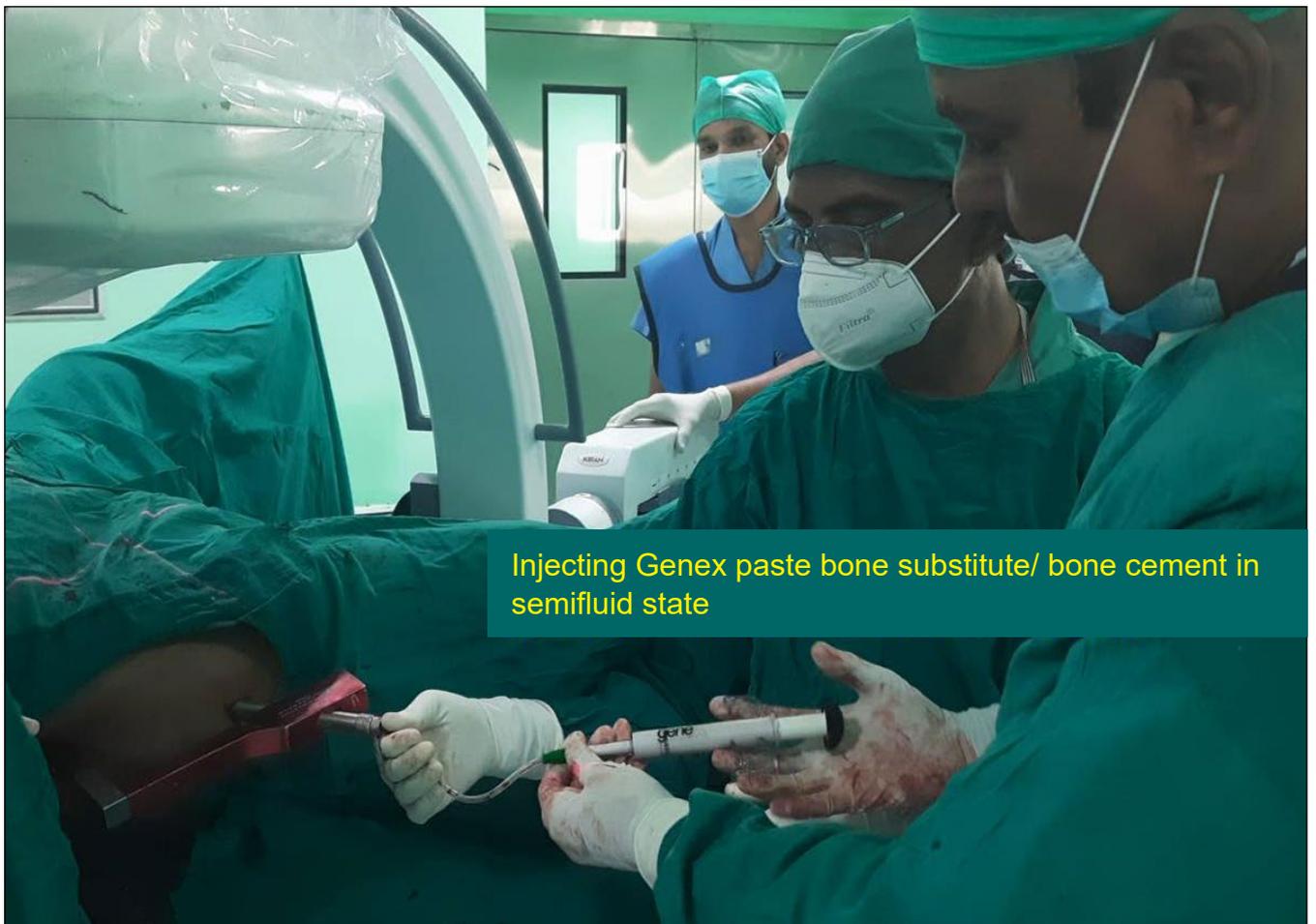
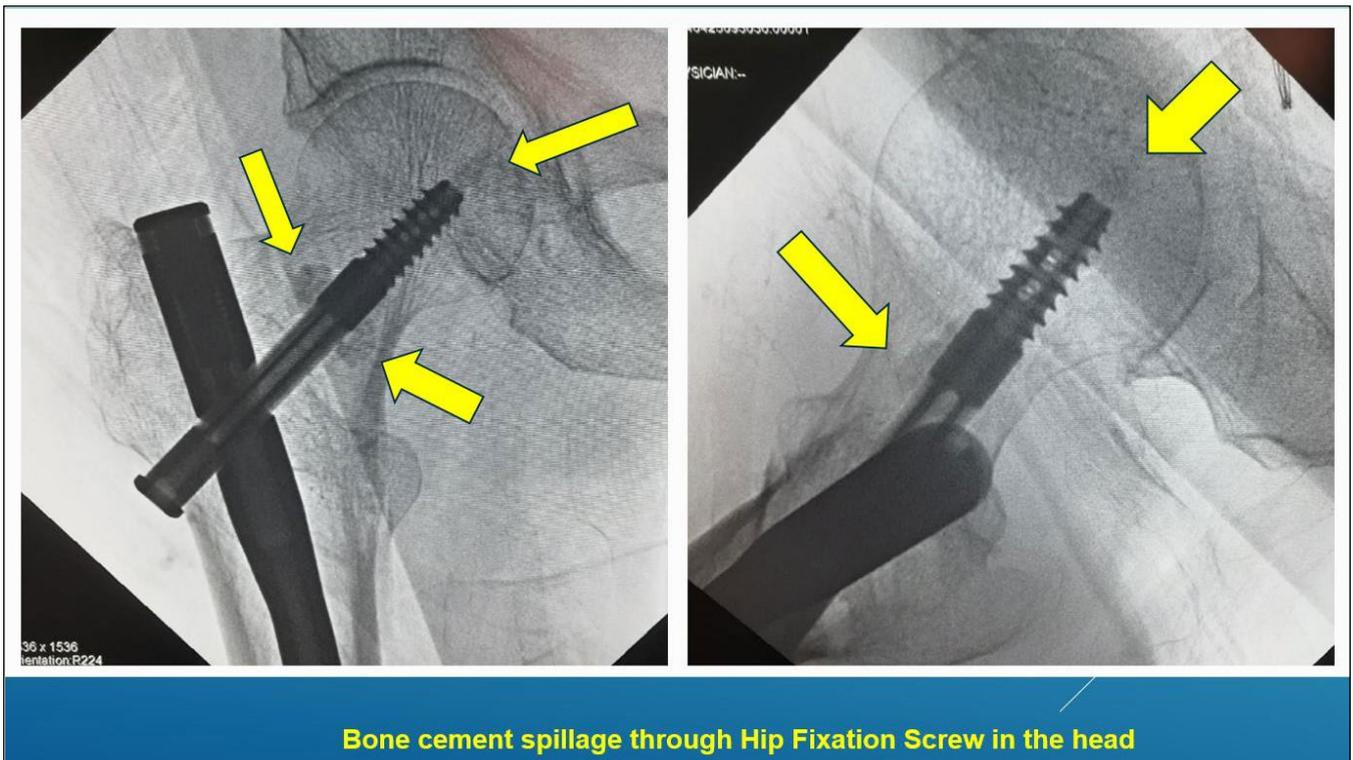
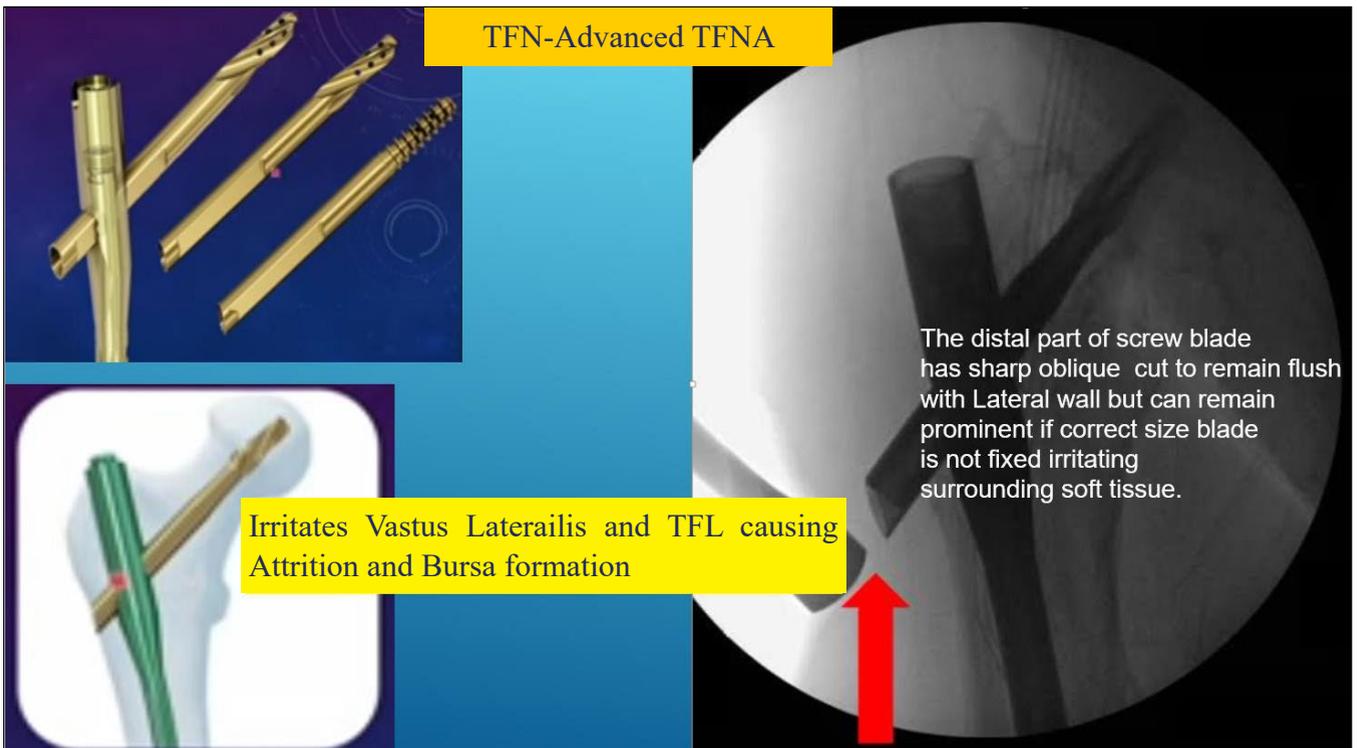


Figure 13: Cement augmentation technique



**Figure 14:** C Arm picture of spillage of liquid bone cement or Genexx paste through HFN cervical screw in the head and neck after injecting



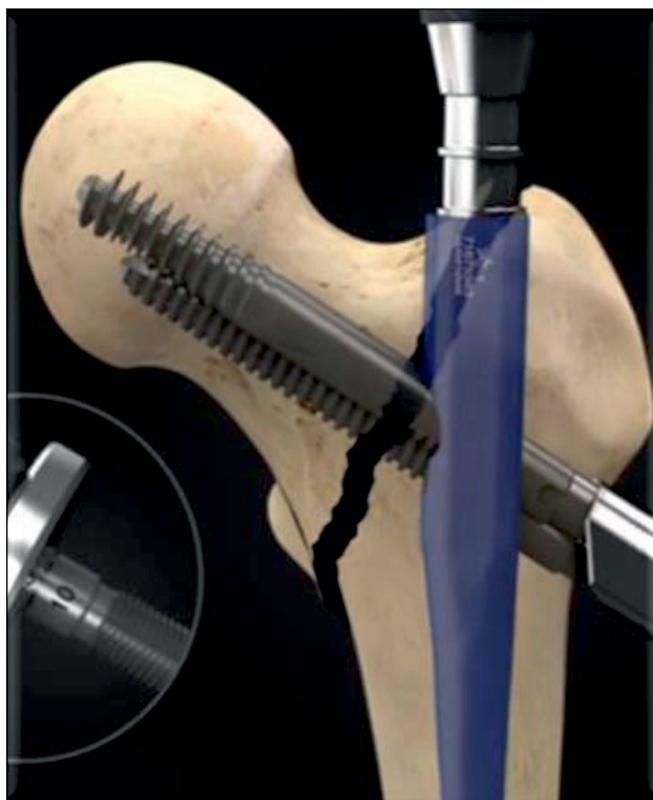
**Figure 15:** Prominence and Irritation of TFNA blade tip on lateral wall irritates if the length of blade is not appropriate

Cement augmentation of proximal femur nail antirotation PFN-A for treatment of osteoporotic pertrochanteric fractures was studied in cadavers.<sup>19</sup> Only TFNA advance single screw /blade has a advantage for cement augmentation by now. Cement augmentation kit comes as a separate kit with TFNA advanced instrument set and the cost is exuberant not

affordable to common man. No other single screw system has this cement augmentation advantage. The length of TFNA blade should be accurate and distal end of blade should seat flush with lateral wall of greater trochanter. If it is more it can irritate vastus lateralis and tensor fascia lata causing pain. **(Figure 15)**

### 2.5.1. Intertan TriGen nail

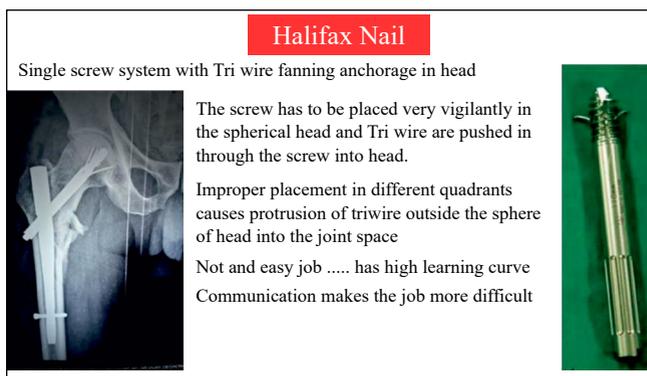
The intertan system offers an integrated interlocking screw option to increase stability and resistance to intra and post operative femoral head rotation eliminating excessive sliding and possible Z effect. The intertan system offers anatomically shaped trapezoidal implant as opposed to conventional circular shaped intramedullary nails. The trapezoidal shape of intertan system enhances stability of the implant in the femur and imparts rotational stability in femoral head neck segment and offer great resistance to cut out. Intertan nail achieves compression by its integrated screw system acting as worm gear mechanism. The compression achieved is maintained independent of lateral wall and is useful in osteoporotic bone. It is fourth generation intramedullary nail.<sup>20,15,21</sup> It has a high learning curve. **(Figure 16)** It is available as short and long intertan nails.



**Figure 16:** Intertan nail integrated screw system

### 2.5.2. Halifax nail

Halifax nail is an innovative trochanteric nailing system that utilizes a patented tri-wire technology to provide additional rotational stability of the fracture neck of femur. Single screw with triwire fanning in head of femur was designed by Dr Subhash Haldar.<sup>22</sup> The cervical screw has to be placed very vigilantly in the center of sphere of femoral head. Improper placement of screw causes triwire fanning eccentrically and can pierce globe of femoral head to pierce in the hip joint. It has high learning curve makes the job more difficult if there is comminution. The screw has no head so augmentation with trochanteric buttress plate is not possible. **(Figure 17)**



**Figure 17:** Halifax nail

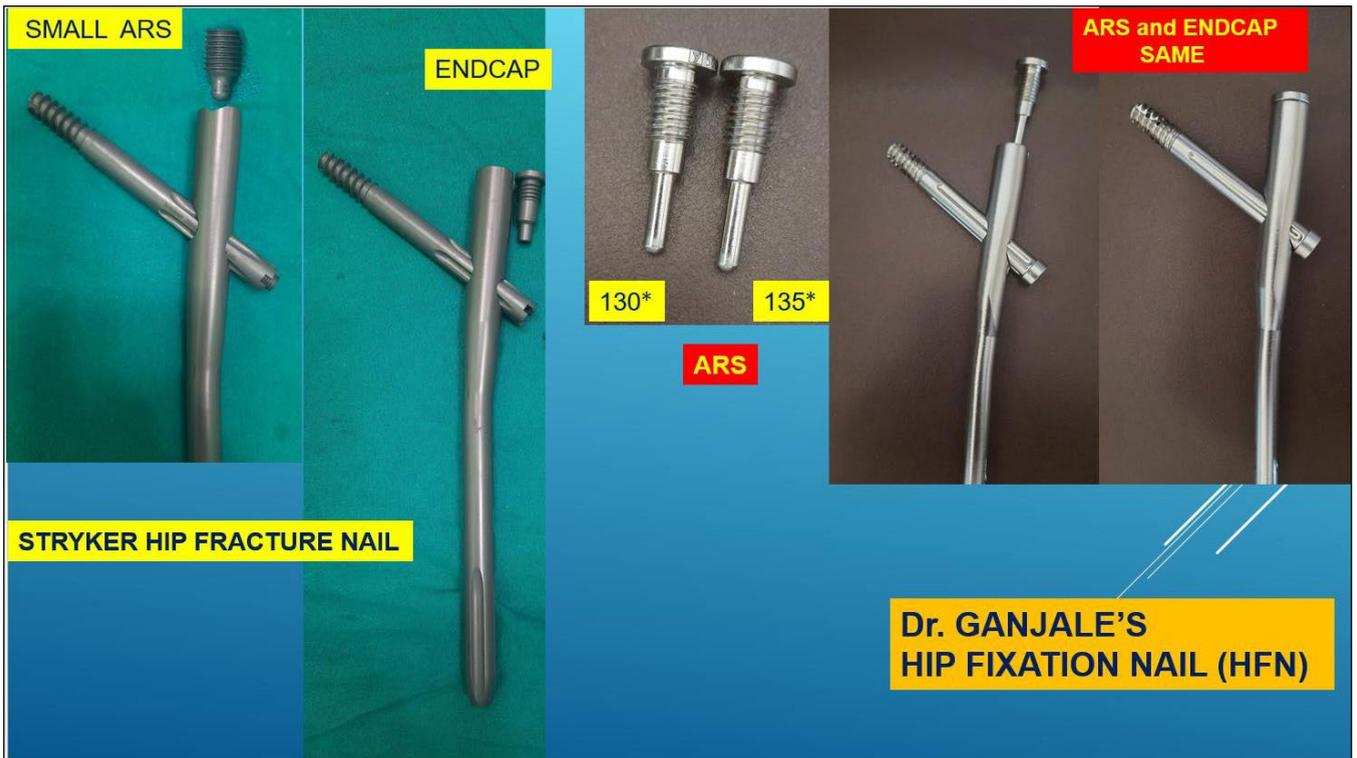
### 2.5.3. Stryker hip fracture nail

The cervical screw has no head and can penetrate in. Trochanteric buttress plate cannot be augmented with this nail. **(Figure 18)**

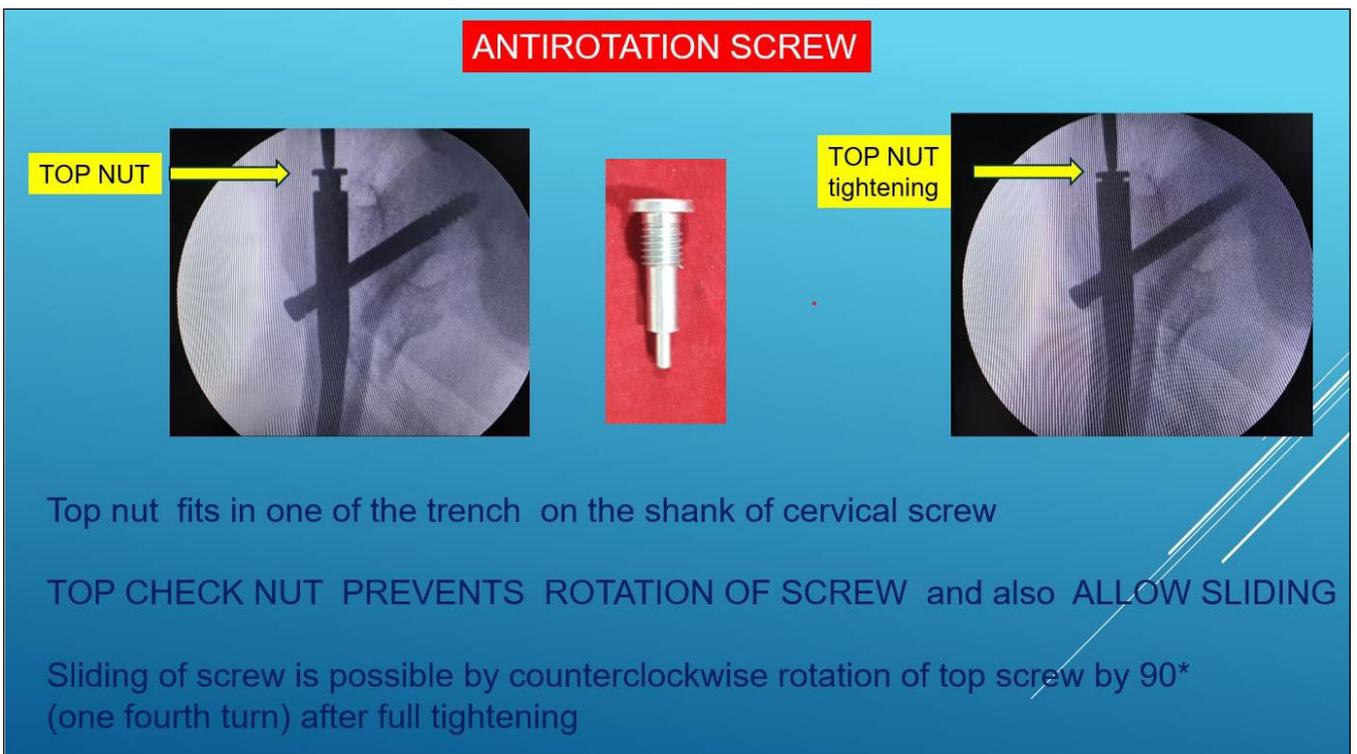


**Figure 18:** Stryker trochanteric hip fracture nail

The antirotation set screw is very small and headless to be inserted in the proximal part of nail to lock the cervical screw. **(Figure 19)** It becomes difficult to pass and screw the antirotation screw into proximal end of nail especially in obese patients. There are chances of misplacing it or fall down from surgeon's hand while inserting it is commonest experience. There is separate end cap to be placed in proximal end of nail to avoid new bone growth so that removal of nail is easy later.



**Figure 19:** Small antirotation screw to be screwed in proximal end of stryker trauson hip fracture nail



**Figure 20:** A Hip Fixation Nail has antirotation screw and end cap is single and same piece.

The author’s Hip Fixation Nail has the end cap and antirotation screw as one piece and insertion into proximal end of nail is easy to lock the cervical screw. **(Figure 19), (Figure 20)**

**2.5.3. Gamma nail**

The proximal end of nail is wide about 17 mm which is cumbersome to pass through trochanter in short statured

Asian population ,and can shatter the trochanteric part while insertion. The cervical screw is 12 mm. and has no head.<sup>23</sup>

**2.5.4. ZNN Zimmer Natural Nail**

The cervical screw has no head and can penetrate in. Trochanteric buttress plate cannot be augmented with this nail.

2.6. Nail designs

The shape of proximal part of the nail is cylindrical and nail shaft is smooth as seen in PFN TFN . M-L (Mediolateral) angle varied from 4 to 6 degrees in different nails. Hip Fixation Nail has 5\* ML angulation. Hip Fixation Nail recently modified for flat lateral surface in proximal portion of nail. Lateral flattening was seen with western nails that have an added advantage as it decreases chances of lateral cortical impingement while inserting the nail and lessen chances of intraoperative lateral wall fracture and intraoperative loss of reduction. Won Chul Shin et al. conducted a study on 100 patients of intertrochantric fractures treated with PFNA and PFNA II and concluded that flat lateral surface of nail can avoid lateral cortical impingement and ensure better fixation. Ref Proximal portion of Intertan nail has trapezoid in shape. Distal interlocking static or dynamic varied in different nails. HFN has both static and dynamic interlocking facility distally. Finally the set screw (Anti rotation screw) at

proximal end of nail can be tightened and kept in static mode or can be released by unscrewing by one fourth turn to allow sliding of cervical screw dynamic mode . Most of the Indian patients have a neck-shaft angle (NSA) varying from 121 to 140 degrees.<sup>3,4,24,25</sup> Many of single screw system nails have only 130\* fixed angle , whereas Hip Fixation Nail comes in two angle nails 130\* and 135\* so optimal choice of implant can be fixed in a given case to have more valgus reduction of neck of femur depending on morphology of bone neck shaft angle.

2.7. Removal of bone in neck of femur (Neck Occupancy of screw /blade)

Femoral Neck diameter is 39.3mm in an average male (Figure 21), (Figure 22), (Figure 23)

AREA = TTr2

Neck  $3.14 \times 18.15 \times 18.15 = 1034$  sq mm

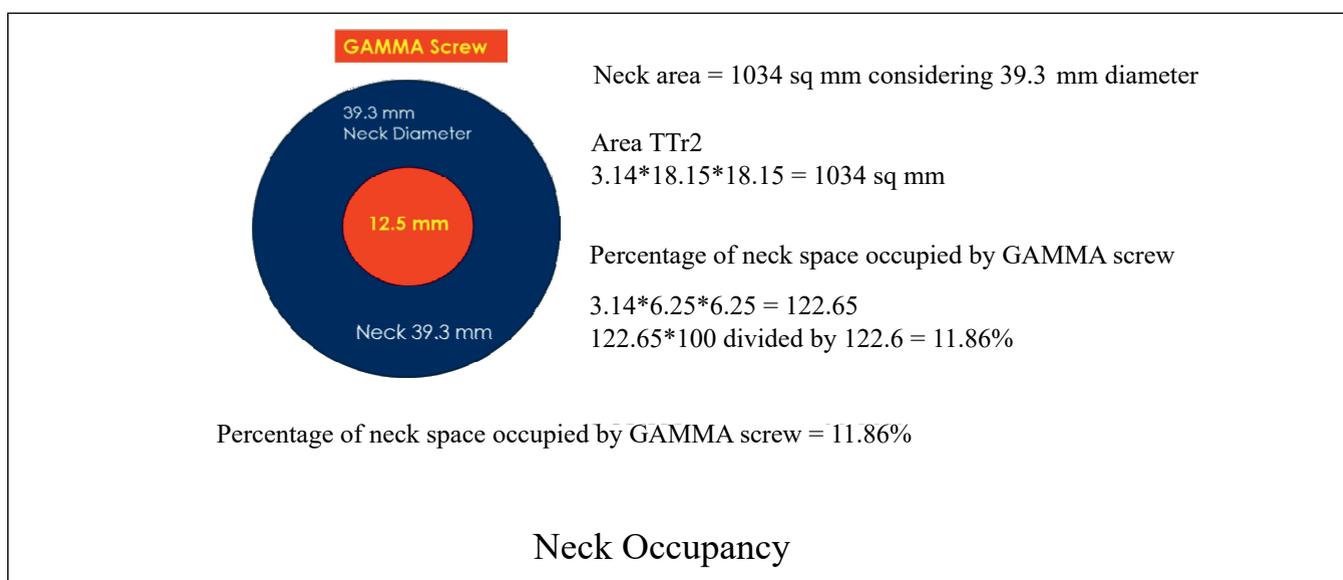


Figure 21: Neck occupancy of Gamma nail screw is 11.86 percent

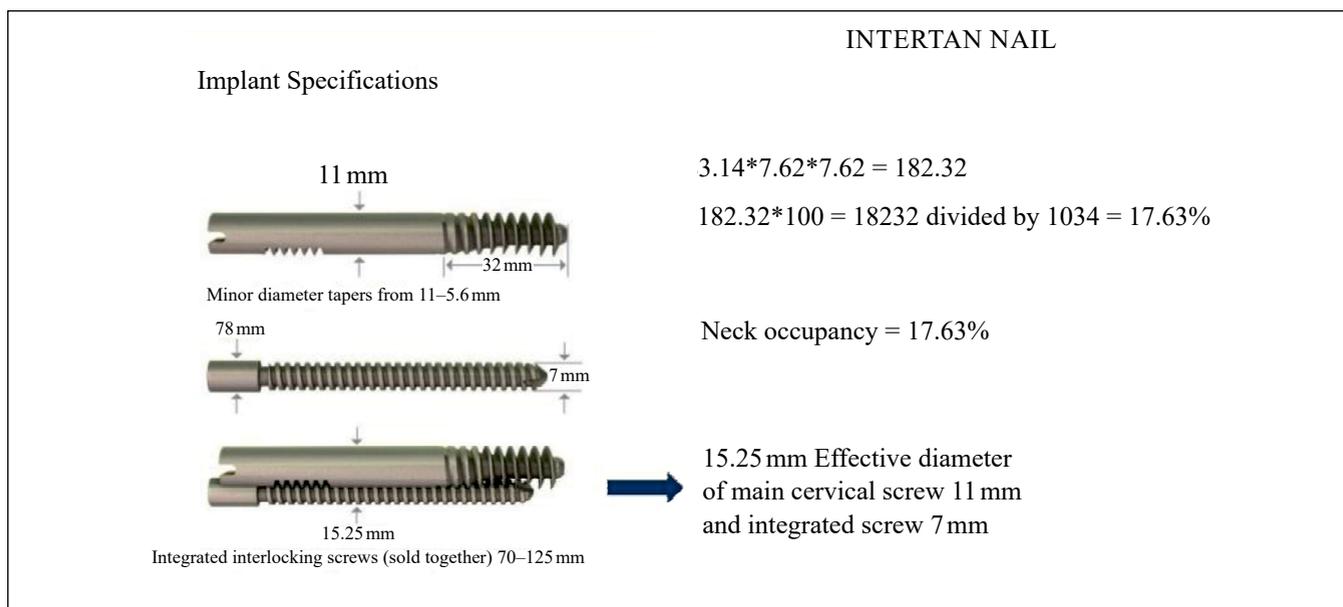
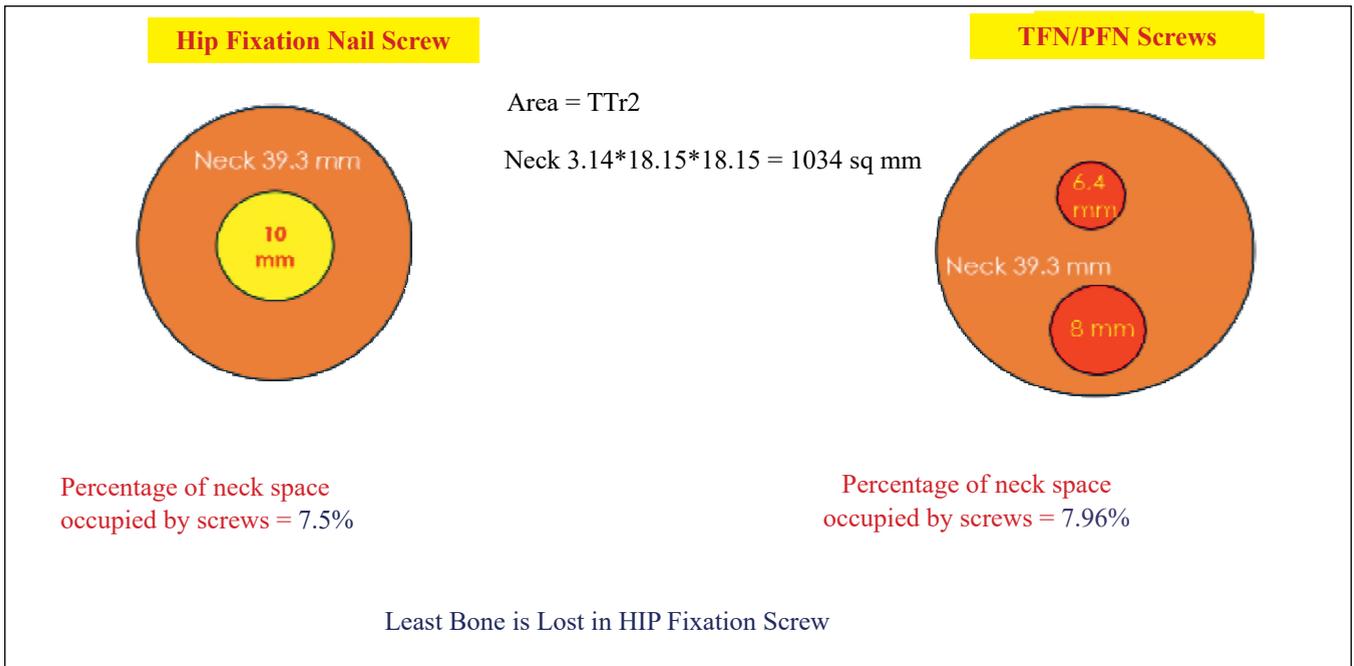


Figure 22: Neck occupancy of Intertan nail is 17.63 percent



**Figure 23:** Neck occupancy of Hip Fixation Nail is 7.5 % where as in TFN and PFN it is 7.96 %

**Table 1:** Advantages of Hip Fixation Nail in a nutshell

Criteria	PFN/TFN Indian	Single screw Gamma/PFNA TFNA /ZNN	Helical blade	Intertan	Dr. Ganjale's HFN
Two points of Fixation	+	-	-	+	+
Compression dependent on bone stock	+	+	+	No	+
Amount of Compression	Unlimited	-	-	Unlimited	Unlimited
Compression dependent on Lateral Wall	+	-	-	No	+
Sliding Lock	-	+	+	+	+
Maintains compression plus allows sliding	+	+/-	+/-	+	+
Screw has head	+	-	-	-	+
Trochanteric Buttress Plate Augmentation	+	-	-	-	+
Cement Augmentation	-	- / only TFNA advanced	-	-	+
Bone removal from head neck (Neck occupancy)	7.9%	11.86%	7.5%	17.63%	7.5%

### 3. Summary: Advantages of Hip Fixation Nail

Richard's Dynamic Hip screw is Gold standard for stable intertrochanteric fractures., but it is surface implant with its single screw and side plate. It cannot be used in unstable intertrochanteric fractures. Intramedullary implants are better than surface implants in treating stable as well as unstable intertrochanteric fractures. Hip Fixation Nail is intramedullary implant with screw in head and neck and a intramedullary nail with decreased abductor lever arm and is a load sharing implant working on principles of DHS in a minimally invasive method of stable fixation with good implant strength.

Hip Fixation Nail is simple cephalomedullary nail with single screw and can be used to fix all stable as well as unstable intertrochanteric fractures . It comes in two angles 130 and 135\* All single screw system nails come only in 130\* neck shaft angle.nail. No other single screw system has 135\* angle nail. (Table 1)

Long HFN is side specific with anatomical bowing as per femur shaft and useful in intertrochanteric fractures associated with shaft fractures and segmental fracture of femur.

1. Much space is available in neck to err for passing guide wire and screw placement.
2. Stable fixation with antirotation top screw. And allows sliding collapse for union.
3. Useful in osteoporotic hips, Removes less bone maintaining the bone stock
4. Gentle screwing achieves compression of fracture site offers optimal compression as per case and is maintained.
5. Head of screw acts as buttress resting on lateral wall of trochanter.

Trochanteric Buttress Plate (TBP) is available in case of lateral wall comminution which is not available in any other single screw system.

Cement Augmentation is added advantage in Hip Fixation Nail for augmentation of fixation in elderly and osteoporotic bones Simple and surgeon friendly, lesser radiation minimal invasive, less operative time consuming minimal instrumentation, easy to use.<sup>1</sup>

Make in India cost effective, cheaper than imported nails, Easily available

HFN.... Hip Fixation Nail is happy fixation nail

#### 4. Conclusion

There is a lot of variation in morphology of proximal femoral nails.<sup>25,13,14</sup> One nail design may be superior in some type of patients and fracture but may not be suitable for others. Orthopaedic surgeons need to consider all the factors in unison while deciding the type of nail to be used depending upon the type of fracture, its comminution, quality of bone, facility to augment the fixation with trochanteric buttress plate in lateral wall comminution, also to address associated shaft and segmental fractures of femur, facility for cement augmentation in osteoporotic bones, availability of nail, cost affordability, surgeon friendly instrumentation, and skill of operating surgeon. Hip Fixation Nail is the simplest cephalomedullary nail for trochanteric and proximal femur fractures and segmental fractures of femur.

#### 5. Conflict of Interest

Nil.

#### 6. Source of Funding

Nil.

#### 7. Acknowledgement

None.

#### 8. Author Contribution

None.

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