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Does the traditional tip-apex distance hold good for PFN-A?

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Abstract

Introduction : Unstable intertrochanteric femoral fractures are common in the elderly, and the incidence of these fractures is continuously increasing worldwide. The aim of the surgical treatment of these fractures is to achieve stable fracture fixation that will allow early weight bearing. Intramedullary device like the proximal femoral nail antirotation has shown a superior cut-out resistance, which may translate into fewer cut-outs in the clinical setting and better functional outcome.

Methods : A prospective study done between October 2018 to October 2019 which included 30 patients with pertrochanteric fractures and were fixed with cephalomedullary nail with a helical blade.

Results : Twenty(66.7%) females and ten(33.3%) males with majority of subjects were in the age group, 71 to 80 years (40%). Mode of injury was self-fall in 93.3% and RTA in 6.7%. 36.7% were A1, 56.7% were A2 and 6.7% were A3 classification. In the study among those with TAD <25, 60% had excellent, 20% had good, 12% had fair and 8% had poor outcome. The implant related complications in our study was significantly less.

Conclusion: The study concludes that TAD of less than 25mm with centre-centre placement of the helical blade showed an excellent to good functional outcome and early post operative mobilization. From our study we believe that TAD rule <25mm should not apply for PFN-A. Although other studies have shown the importance of the tip-apex distance, our study does not recommend it.

Keywords: Intertrochanteric (IT), Tip-apex distance (TAD), Proximal Femoral Nail Antirotation(PFNA), Arbeitsgemeinschaft für Osteosynthesefragen /Association for the Study of Internal Fixation (AO/ASIF**)**

Introduction

Unstable proximal femoral fractures are common and challenging for the orthopaedic surgeon. The aim of the surgical treatment of these fractures is to achieve stable fracture fixation that will allow early weight bearing. Many different devices have been developed, yet mechanical failures still occur. The complication rate is quoted as being from 15% to 20%, with the most common mode of failure being screw or blade cut-out.[1] In biomechanical studies, the spiral blade of the Synthes proximal femoral nail antirotation (PFNA; Synthes GmbH, Oberdorf, Switzerland) has shown a superior cut-out resistance, which may translate into fewer cut-outs in the clinical setting [1]. The technique guide for this implant suggests a distance from the blade tip to the joint level of 10 mm in the anteroposterior and lateral projections [1]. This corresponds to a tip-apex distance of 20 mm. When using a sliding hip screw and plate construct, a tip-apex distance (TAD) of less than 25 mm and centre-centre positioning has been established as a major factor to minimise the risk

of cut-out. In this study we will investigate the ideal position of the helical blade in the femoral head and if the traditional tip-apex distance holds good for the helical blade device .

Aim

The objective of this study was to investigate the ideal position of the helical blade in the femoral head and if the traditional tip-apex distance holds good for the helical blade device .

Methodology

Among the patients with intertrochanteric fractures who were admitted to Rajarajeshwari medical college and hospital who underwent surgical treatment with an cephalomedullary nailing with helical blade (proximal femoral nail antirotation [PFNA]; Synthes), hospitalized between October 2018 and October 2019 which included 36 patients. We prospectively collected all of the variables that are shown in the tables and figures. Pre-operative radiographs were used to classify the fractures according to Arbeitsgemeinschaft für Osteosynthesefragen/Association for the Study of Internal Fixation (AO/ASIF).

Internal Fixation and Subsequent Weight-Bearing

The patients were positioned supine on a traction table and were placed under spinal or general anaesthesia. We performed a closed reduction approach with the use of traction along the axis of the limb with the femur placed in internal or external rotation, and with an image intensifier (C-arm) used in the preoperative planning to obtain the correct alignment and morphology of the femur with reference to the healthy side. After confirming reduction on antero-posterior and lateral radiographs for limited open surgery, we performed internal fixation using a PFNA and 3 small incisions. During PFNA fixation, we first decided on an optimal entry point, which was at the tip of the greater trochanter, and then reamed to make it possible to prevent loss of reduction by gently introducing the nail. The PFNA has an impaction nail component that is used for the femoral head. A helical blade inserted into a nail with an appropriate proximal geometry. We placed the blade in the femoral head to attain stability of the blade on anteroposterior and lateral radiographs and minimize the tip-apex distance (TAD). The position of the blade was stable when it was positioned in the central-central or the central-superior zone of the femoral head by dividing the head into 3 zones on the antero-posterior radiograph and 3 zones on the lateral radiograph. The position was plotted on the sagittal plane as seen on the postoperative radiograph to obtain better resistance against rotation of the femur after surgery. Finally, we inserted a distal locking screw using the aiming arm device. Radiographic evaluations were performed preoperatively, immediately postoperatively, and 6 weeks, 3 and 6 months after surgery. After postoperative radiography confirmed the absence of displacement of the PFNA and the correct morphology of the fixed femur, we allowed early mobilization and full weight-bearing.

In our hospital, we used Harris Hip Score for functional follow up of the patient. Out of 36 patients, 6 were excluded from the study, 2 patients were not available for follow up and 4 patients expired due to medical illness unrelated to the fracture

Statistical analysis

Data was entered into Microsoft excel data sheet and was analyzed using SPSS 22 version software. Categorical data was represented in the form of Frequencies and proportions. **Chi-square test** was used as test of significance for qualitative data. Continuous data was represented as mean and standard deviation. **Graphical representation of data:** MS Excel and MS word was used to obtain various types of graphs such as bar diagram, Pie diagram. **p value** (Probability that the result is true) of <0.05 was considered as statistically significant

after assuming all the rules of statistical tests. **Statistical software:** MS Excel**,** SPSS version 22 **(**IBM SPSS Statistics, Somers NY, USA) was used to analyze data.

Results

Table 1: Profile of subjects in the study

		Count	%
Age	**<60 years**	**6**	**20.0%**
	61 to 70 years	**5**	**16.7%**
	71 to 80 years	**12**	**40.0%**
	80 to 90 years	**7**	**23.3%**
Sex	**Female**	**20**	**66.7%**
	Male	**10**	**33.3%**
Mode Of Injury	**RTA**	**2**	**6.7%**
	Self-fall	**28**	**93.3%**
Classification	**31A1**	**11**	**36.7%**
	31A2	**17**	**56.7%**
	31A3	**2**	**6.7%**
Side	**Left**	**15**	**50.0%**
	Right	**15**	**50.0%**

In the study majority of subjects were in the age group, 71 to 80 years (40%), 66.7% were females and 33.3% were males. Mode of injury was self-fall in 93.3% and RTA in 6.7%. 36.7% were A1, 56.7% were A2 and 6.7% were A3 classification and 50% were left side and right side injury. (Table1)(Figure1)

Postoperative radiographs were analysed for TAD and Cleveland zone. The TAD was assessed on the immediate postoperative radiographs using the method described by baumgaertner et al. The TAD ranged from 14.4mm to 32mm with 25(83%) cases having under 25.

The location of the helical blade in the femoral head was evaluated by the Cleveland method shown in Figure-2. In a total of 16 patients (53.33%) the position was centre-centre. 1 patient had centre-posterior , 4 patients with superior anterior and 9 patients with superior-centre. Hence the centre- centre was the most common placement of the helical blade. (Figure-3)

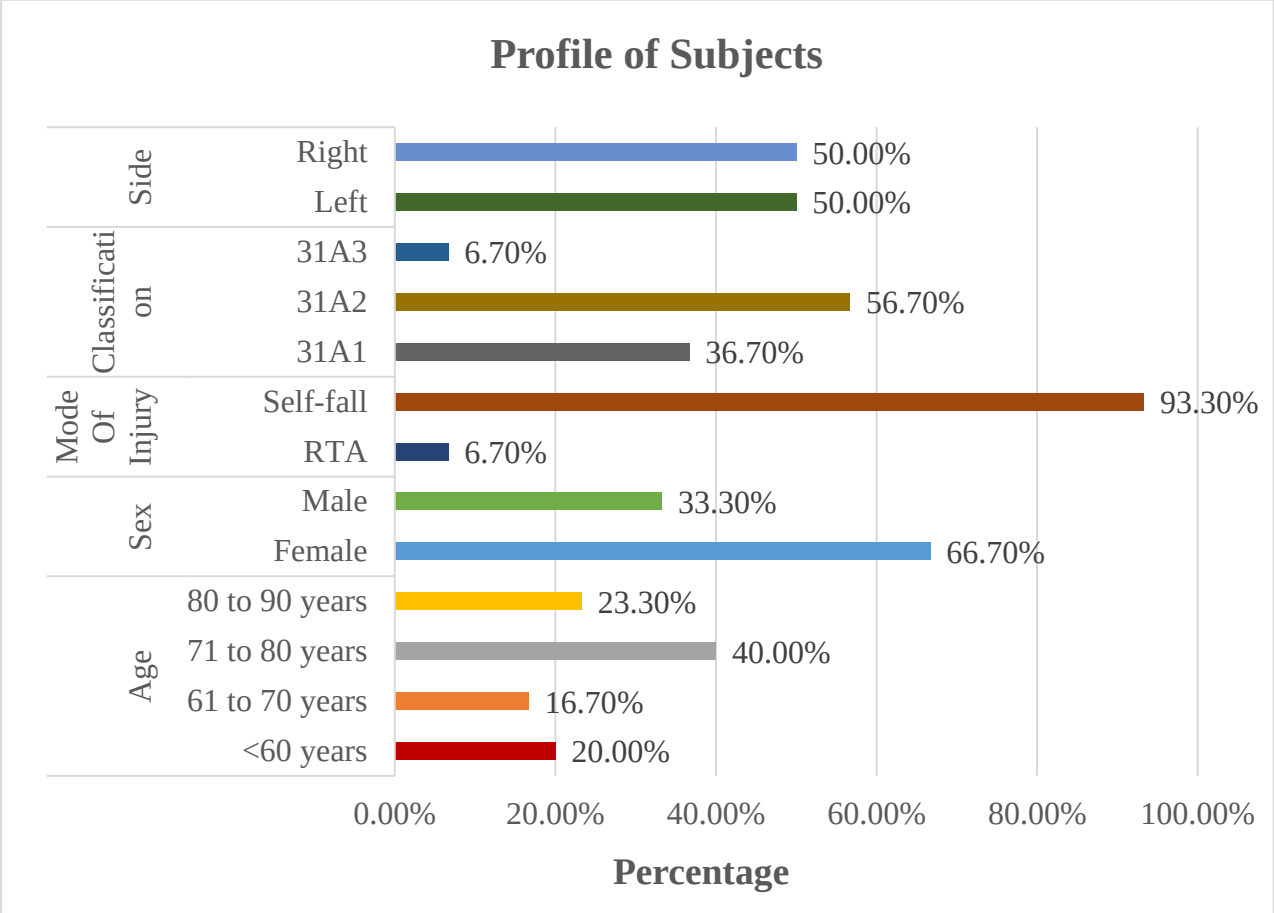


Figure 1: Bar diagram showing Profile of subjects in the study

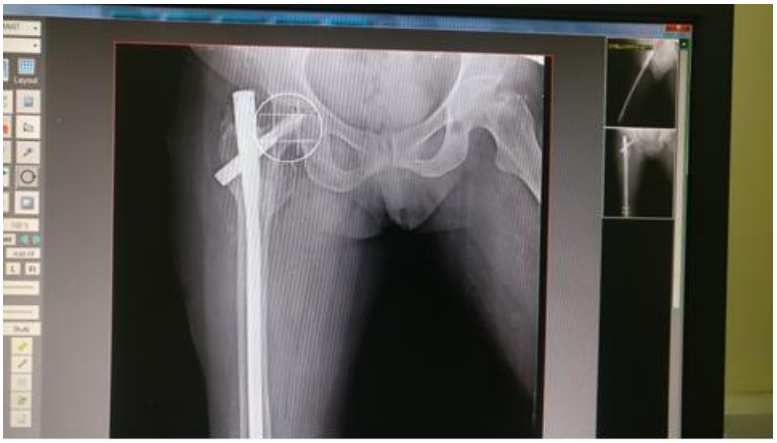


Figure 2: cleveland zones [1]

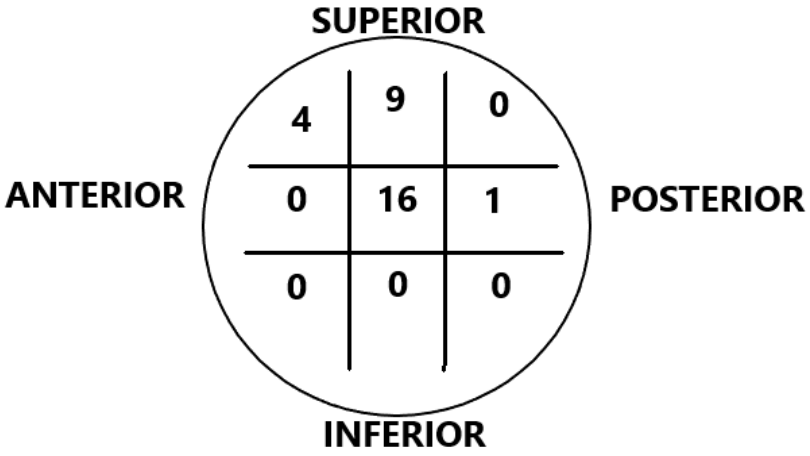


Figure 3: Cleveland index distribution

The average time to clinical follow up was 6 months. Clinical follow up of the patient was done by the Harris Hip scoring system, in which 24 patients had an excellent to good result and 3 patients with fair and 4 patients with poor results.
20 patients were advised for weight bearing mobilization within 7 days post operatively, ranging from 3 to 21 days.
In a total of 30 patients, 24 patients underwent closed reduction and 6 patients underwent open reduction.

Complications- There were no implant related complications, but 2 patients had a superficial infection and 2 patients had a varus reduction of the fracture. The patient was continued with oral antibiotics for a duration of 1 week for infection and for the varus reduction the patient was counselled for delayed weight bearing mobilization (Table 2), (Figure 4).

Table 2: Type of reduction and complication distribution

		Count	%
Reduction	**Closed**	**24**	**80.0%**
	Open	**6**	**20.0%**
Complication	**Nil**	**26**	**86.7%**
	Infection	**2**	**6.7%**
	Varus Reduction	**2**	**6.7%**

In the study 80% had closed reduction and 20% had open reduction. 6.7% had infection and 6.7% had varus reduction.

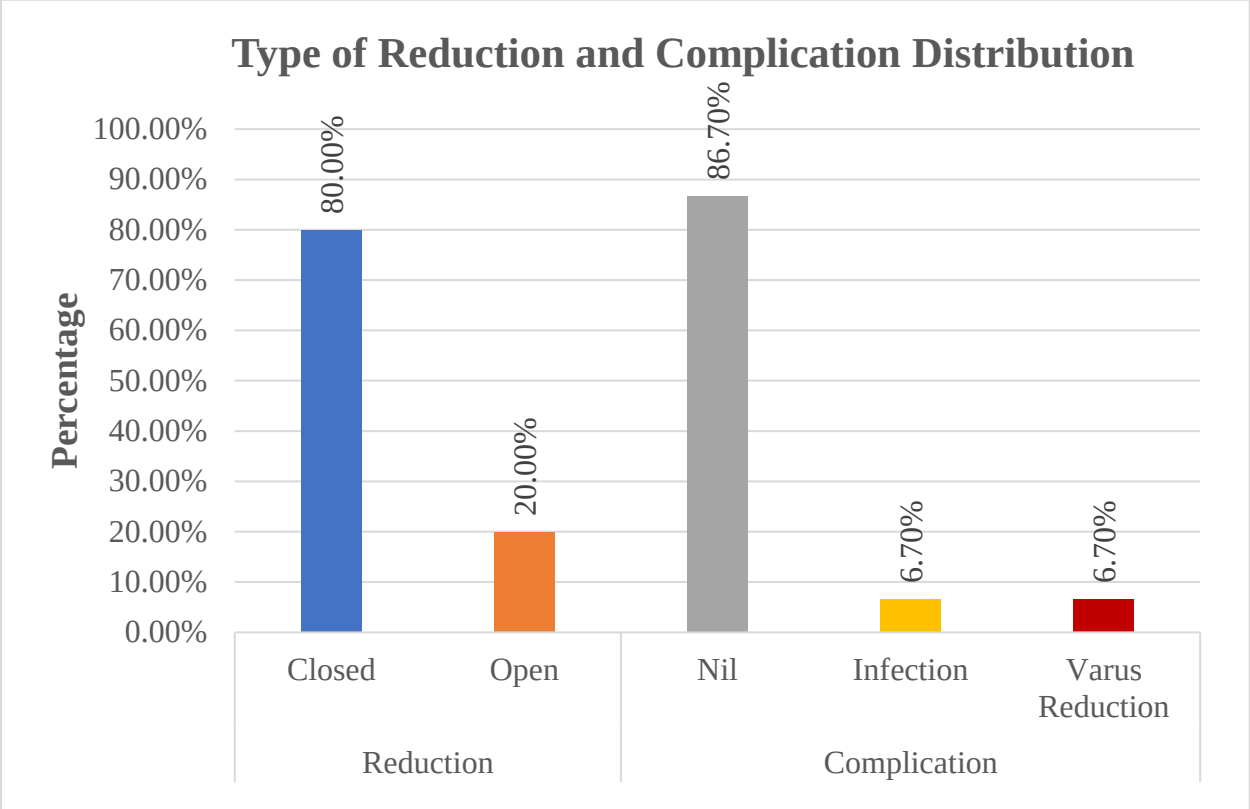


Figure 4: Bar diagram showing Type of reduction and complication distribution

In this study there was association between TAD to functional outcome was significant (p=0.027) (Table.3). In the study among those with TAD <25, 60% had excellent, 20% had good, 12% had fair and 8% had poor outcome (figure 3). In the study there was significant association between TAD and Cleveland index(p=0.013) (table 3) i.e. among those with TAD <25, 68% had CC, 4% had CP, 16% had SA and 12% had SC and among those with TAD >25, 20% had CC and 80% had SC(Figure 5), (Table 3).

Table 3: Association between TAD and Functional outcome

		TAD			
		<25		>25	
		Count	%	Count	%
Functional outcome	Excellent	15	60.0%	0	0.0%
	Good	5	20.0%	4	80.0%
	Fair	3	12.0%	0	0.0%
	Poor	2	8.0%	1	20.0%

$\chi 2 = 9.2$, df =3, p =0.027*

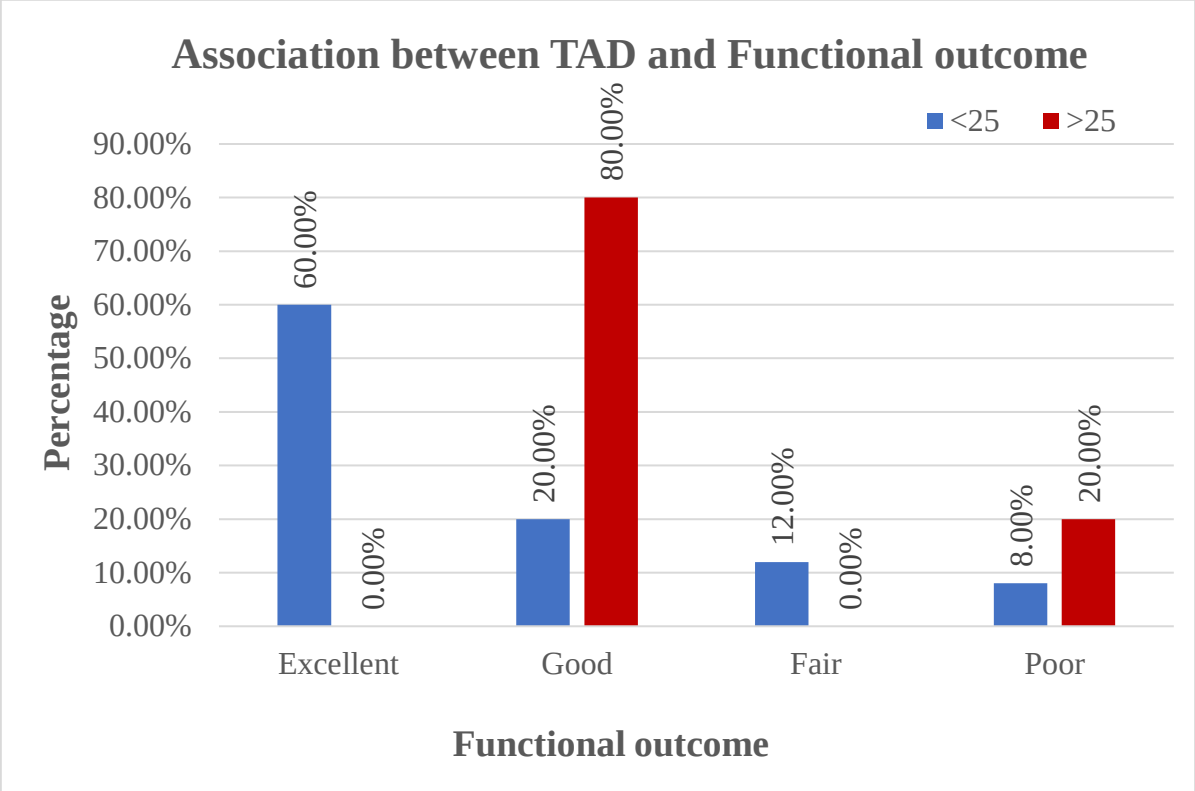


Figure 5: Bar diagram showing Association between TAD and Functional outcome

In the study there was significant association between Cleveland index and Functional Outcome ($p<0.001$)(table 4). I.e. among those with CC, 83.3% had excellent, 16.7% had fair outcome. Among those with CP, 100% had good outcome, among those with SA, 50% had good and 50% had poor outcome and among those with SC, 85.7% had fair and 14.3% had poor outcome (Figure 6), (Table 4).

Table 4: Association between Cleveland index and Functional outcome

		Cleveland index							
		CC		CP		SA		SC	
		Count	%	Count	%	Count	%	Count	%
Functional Outcome	Excellent	15	83.3%	0	0.0%	0	0.0%	0	0.0%
	Good	0	0.0%	1	100.0%	2	50.0%	0	0.0%
	Fair	3	16.7%	0	0.0%	0	0.0%	6	85.7%
	Poor	0	0.0%	0	0.0%	2	50.0%	1	14.3%

$\chi 2 = 45.2$, df $= 9$, $p < 0.001$*

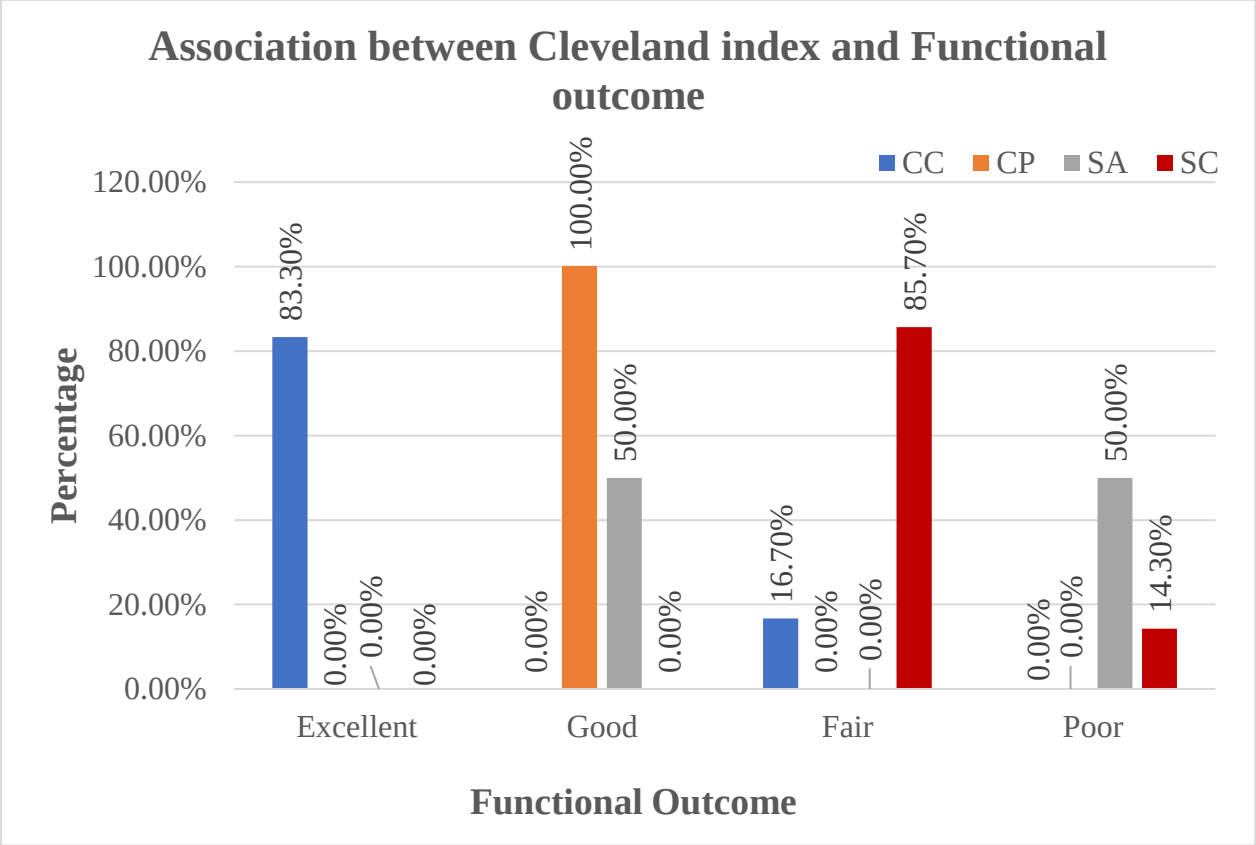


Figure 6: Bar diagram showing Association between Cleveland index and Functional outcome

In the study there was significant association between TAD and day of weight bearing(p=0.018)(table 5). i.e. among those with TAD <25, 60% had weight bearing within 5 days, 12% between 6 to 10 days and 28% after 10 days. Among those with TAD >25, 0% had weight bearing within 5 days, 60% b/w 6 to 10 days and 40% after 10 days (Figure 7),(Table 5).

Table 5: Association between TAD and Day of weight bearing

		TAD			
		<25		>25	
		Count	%	Count	%
Day of weight bearing	<5 days	15	60.0%	0	0.0%
	6 to 10 days	3	12.0%	3	60.0%
	>10 days	7	28.0%	2	40.0%

χ 2 =8.0, df =2, p = 0.018*

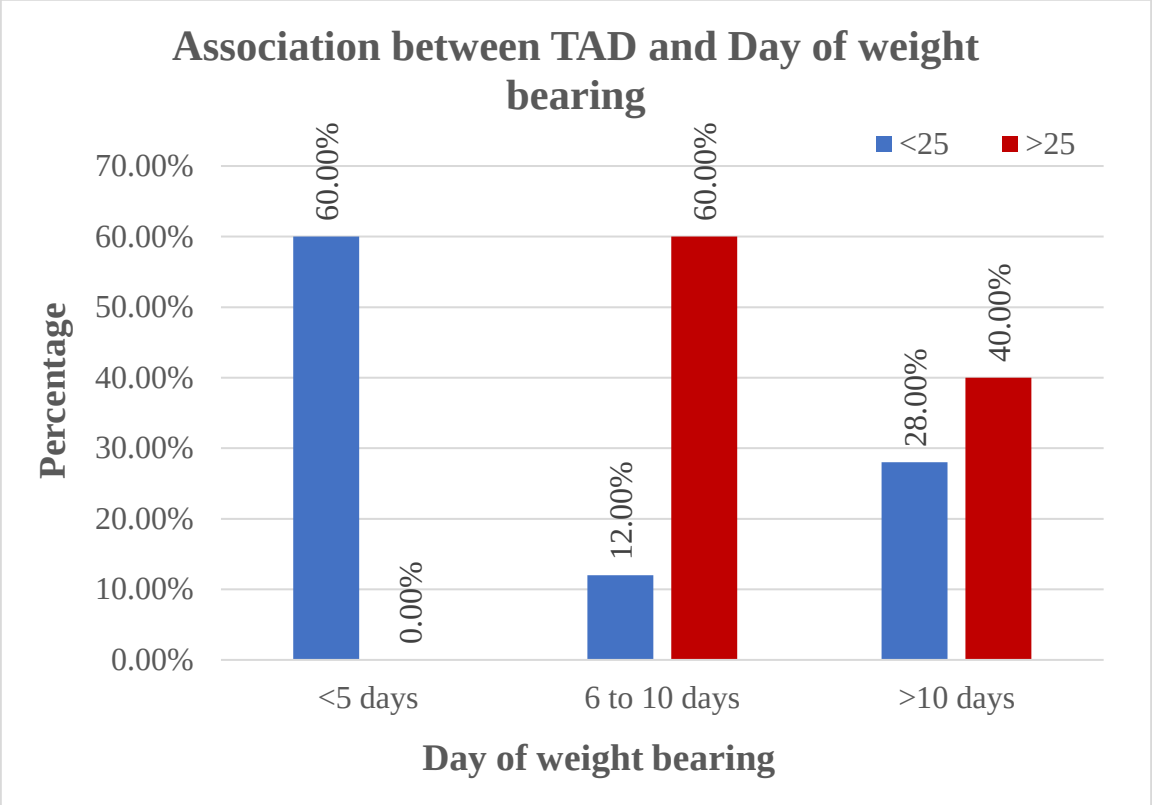


Figure 7: Bar diagram showing Association between TAD and Day of weight bearing

Table 6: Association between TAD and Cleveland index

		TAD			
		<25		>25	
		Count	%	Count	%
Cleveland index	CC	17	68.0%	1	20.0%
	CP	1	4.0%	0	0.0%
	SA	4	16.0%	0	0.0%
	SC	3	12.0%	4	80.0%

$\chi 2 = 10.8$, df =3, p =0.013*

In the study there was significant association between TAD and Cleveland index i.e among those with TAD <25, 68% had CC, 4% had CP, 16% had SA and 12% had SC and among those with TAD >25, 20% had CC and 80% had SC (Table6), (Figure 8).

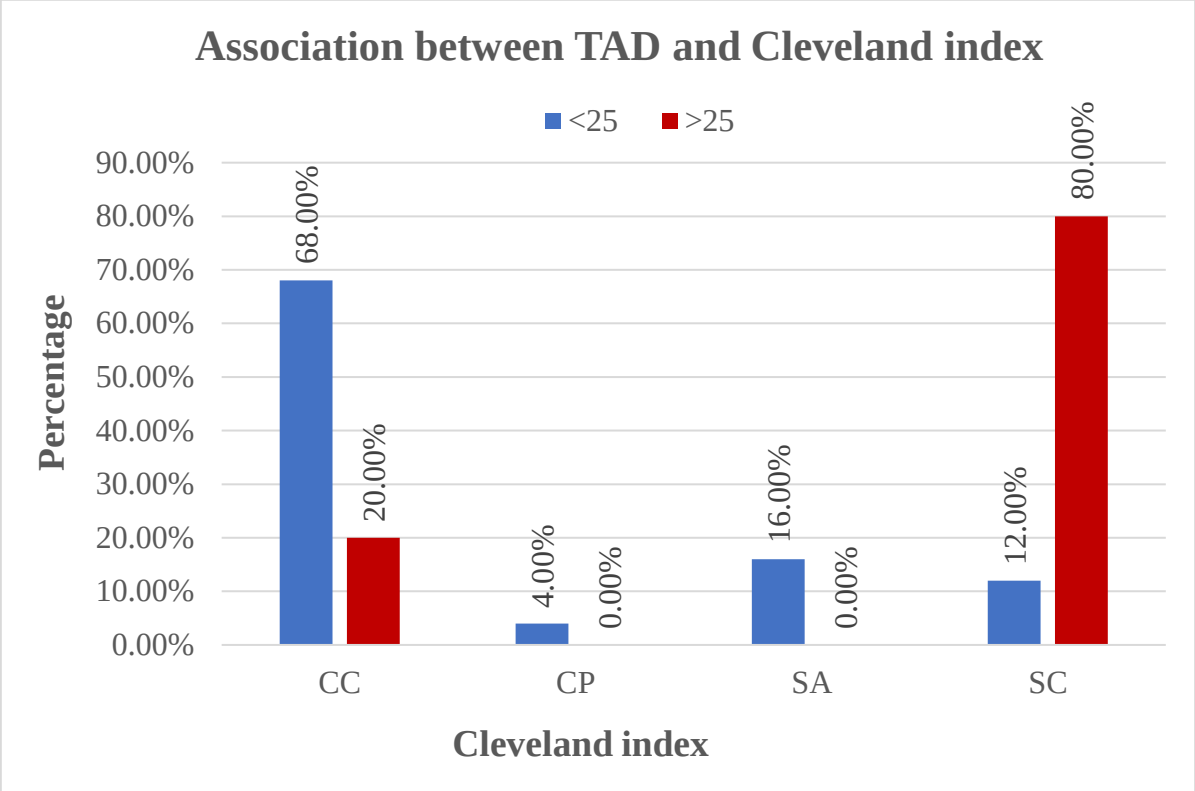


Figure 8: Bar diagram showing Association between TAD and Cleveland index

From these statistical analysis, the study concludes that TAD of less than 25mm with centre-centre placement of the helical blade showed an excellent to good functional outcome and early post operative mobilization . The implant related complications in our study was significantly less.

Clinical Images

Case 1

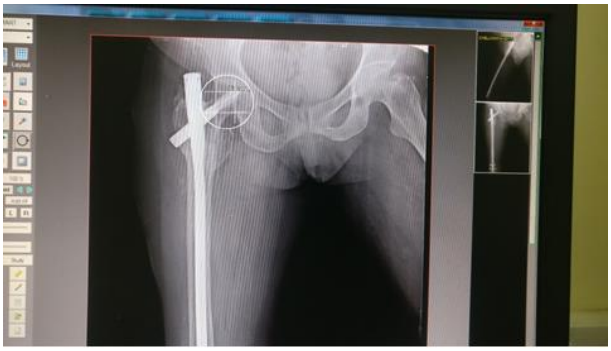
Pre-operative x-ray

Post-operative x-ray

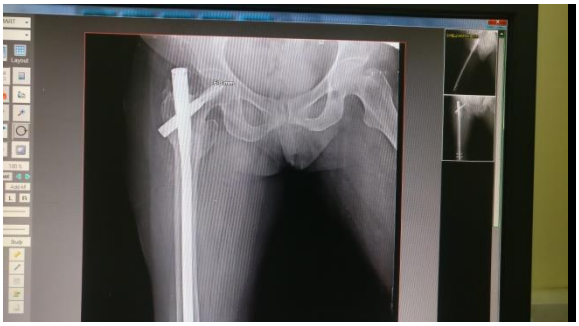
6weeks post-operative x-ray

3months post-operative x-ray

6months post operative x-ray



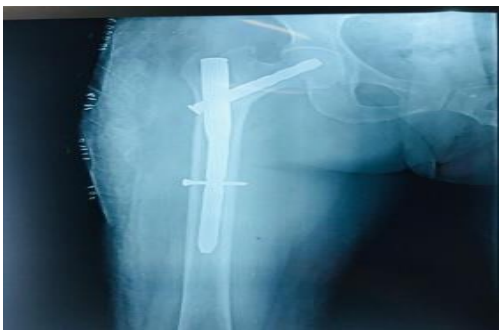
cleveland zones &TAD of case1




Adduction **Abduction**


flexion

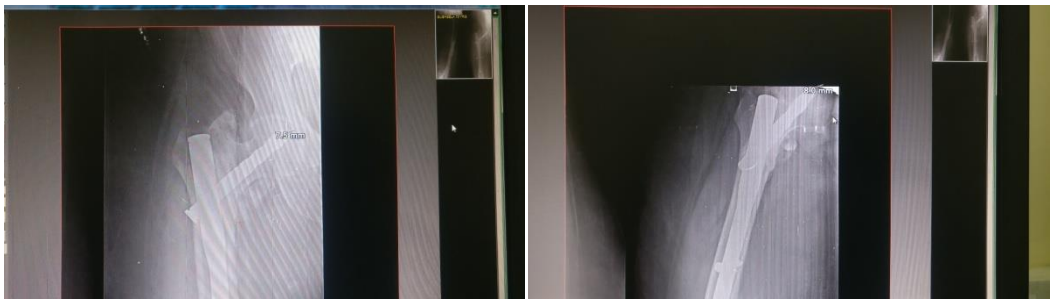
Case 2

Pre-operative x-ray **post-operative x-ray**


6weeks post-operative x-ray **3 months post-operative x-ray**

6 months post-operative x-ray



TAD and cleveland zones of case 2

Flexion

Abduction **Adduction**

Discussion

The purpose of this study was to define the ideal placement of the helical blade in the femoral head and to show that the TAD did not matter in proper placement of the helical blade in the femoral head.

The change to a helical blade with the introduction of the PFNA was intended to reduce the likelihood of cut-out and to eliminate the occurrence of the Z-effect mode of failure of the old PFN[1].

In our study we had no cut out. Several clinical studies reported cases of cut-out with PFNA. Brunner et al., reported 3 cases of cut-out, out of 12[3]. In the above study they have stated that the reason for cut-out being the helical blade design, which may result in medial perforation of the subchondral bone. Mereddy et al. had 2 cases in their series of 62 [4]. They

reported their TAD as <20 mm in 79% of the total cases but did not report what the TAD was in cases of cut-out. Penzkofer et al. reported 3 cut-outs in their cohort of 66 pertrochanteric and subtrochanteric fractures treated with PFNA [5]. Takigami et al. had 1 cut-out in their series of 50 pertrochanteric fractures treated with PFNA for unstable fractures [6]. Simmermacher have the largest series to date, with a reported cut-out rate of 4 out of 313 cases [7].

The optimal helical blade position in our study 16 patients (53.33%) had a centre-centre placement. Anirudh Sharma et al showed that 17 patients of 25(68%) had an optimal implant position i.e. centre-centre[8]. Several previous studies demonstrated that the optimal position of the blade within the femoral head is one of the most important factors to prevent mechanical failure of the osteosynthesis. A centre–centre or an inferior–centre position of the blade are commonly recommended[[9],[10],[11],[12]. In our study, the results showed that with a centre-centre position of the helical blade had a good functional outcome at the end of 6 months without any implant- related complications.

Hwang et al., in a biomechanical evaluation of proximal femoral nail antirotation in cadavers showed that placement of the helical blade inferior-centre was superior the centre-centre group and provided better stability[2]. But our study showed that centre-centre placement of helical blade has better stability as early weight bearing mobilization was advised for patients with centre-centre placement.

The significance of the TAD of less than or equal to 25 mm to limit the risk of cut-out was first described by Baumgartner et al [13] and has been confirmed in several studies for both sliding hip screws and PFN[14],[15],[16] .Our study also supports the importance of TAD of less than or equal to 25mm but with proper placement of the helical blade i.e.centre-centre in the femoral head and whatever might be the TAD the patient had an excellent to good functional outcome at the end of 6 months.

Limitations of the study

- Being a single centre trial, our study has the limitation of a small sample size, operated by senior surgeons. Due to the short period of follow up (minimum 6 months), we cannot comment on the long term complications, if any.
- The type of reduction of fracture was evaluated intra operatively chief surgeon on fluoroscopy and not post-operatively on radiography.
- In our study we did not carry out a radiographic evaluation of the degree of osteoporosis according singhs index or by dexa scan to rule out any implant related complications due to quality of the bone.
- For the evaluation of the TAD and Cleveland index fixed magnification was considered as per the institutions availability.

Conclusion

From our study we believe that TAD rule <25mm should not apply for PFN-A. It is important that the helical blade be placed in centre-centre with any TAD. The functional outcome ranges from excellent to good at the last follow up. The position of the blade represents one of the main parameters associated with poor functional outcome. Although other studies have shown the importance of the tip-apex distance, our study does not recommend it.

Conflict of interest

On behalf of all authors ,the corresponding author states that there is no conflict of interest .

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