Is the Femoral Neck Geometry Adequate for Placement of the Proximal Femoral Nail in the Malaysian Population? A Review of 100 Cases

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SUMMARY

Issues that had been encountered during proximal femoral fracture fixation using proximal femoral nail include i) the adequacy of the femoral neck width in the local population and ii) the potential difficulty encountered during fixation in certain prefixed angles as determined by the implant. This was a retrospective, descriptive study evaluating the anterior-posterior pelvic radiographs of 100 consecutive patients, from January to August 2007, managed at University Malaya Medical Centre, Kuala Lumpur. The femoral neck width in the population studied was adequate for placement of femoral neck screw and anti-rotation pin or hip pin using the proximal femoral nail implant. (mean = 34.0±3.7mm, min = 24.6mm). There was no significant difference between the working area using an implant angled at 130° or 135° (*P*=0.91). Both femoral neck width and neck shaft angle of the Malaysian population studied were not a factor influencing the placement of femoral neck lag screws and anti-rotation pin.

KEY WORDS:
Femur neck, Intramedullary nailing, Hip fractures, Intertrochanteric fractures, Subtrochanteric fractures

INTRODUCTION

Intramedullary devices are fast becoming popular methods for fixation of intertrochanteric and subtrochanteric fractures[1,2,4,5,6]. They are preferred to the conventional dynamic hip screw fixation as the latter requires a larger surgical wound exposure, more soft tissue handling and anatomical reduction, hence possibly causing an increase in morbidity due to blood loss and infection. Furthermore, intramedullary devices are biomechanically more superior[2,3]. Various studies has shown the superiority of intramedullary proximal femoral devices in the fixation of unstable or complex intertrochanteric fractures and subtrochanteric fractures[2,4,5,6].

In Malaysia, intramedullary proximal femoral nail (PFN) is a commonly used device for the fixation of proximal femoral fractures. But there are two technical issues that need to be addressed when using this implant. First, the width of the femoral neck of the Malaysians population has not been previously studied. Generally, it was deemed smaller than that of the Caucasian population as the build of the local population is smaller as well. This may potentially lead to an increased difficulty in placement of femoral neck screws and anti-rotation pins. Secondly, the need for fixation in certain prefixed angles as determined by the implant construct may alter the width of the neck that needs to be negotiated in order to insert the implant safely, thus making the working area narrower and increase the difficulty of the procedure. This may lead to an inadequate placement of the anti-rotation pin, the usage of an anti-rotation pin that is too short or even omitting the placement of an anti-rotation pin. Thus, the stability of the fracture fixation may be compromised.

We undertook this study to evaluate the adequacy of femoral neck geometry for the placement of PFN in a Malaysian population.

MATERIALS AND METHODS

This was a retrospective, descriptive study, conducted at the Department of Orthopaedic Surgery, University Malaya Medical Centre (UMMC), Kuala Lumpur. Consecutive patients aged 18 years old and above, who were evaluated at the department from January to August 2007, and had an anterior-posterior (AP) pelvic radiographs performed at UMMC were recruited. Only cases with adequate AP radiographs were included. Adequate AP pelvic radiographs were defined as pelvic projection films that visualized the entire pelvis in true AP position, including the 5th lumbar vertebra, sacrum and coccyx, as well as the proximal femurs, including the both trochanters which were demonstrated along the medial borders of the femurs. Patients with radiographs that did not fulfill the above criteria were excluded. In those cases that presented with hip fractures or proximal femoral fractures, the contralateral normal side of the proximal femur was evaluated.

The following data were collected: patient's age, gender, race, neck shaft angle (NSA), narrowest femoral neck width at NSA (NW), narrowest femoral neck width at 130° with the femoral axis (NW130) and narrowest femoral neck width at 135° with the femoral axis (NW135). (130° and 135° are the common preset PFN implant angle between the nail and the lag screw used in this centre.) The measurements were carried out with computerized radiographic imaging software IMPAX 6.2.1.135 (AGFA Gaveart N.V, Mortsel Belgium). (Fig. 1)

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The definitions used in the present study are shown in Table I.

Control: Error in measurements was expressed in calculating the percentage of error in subjects by measuring the lag screw diameter and comparing it to the manufacturer's lag screw diameter size. Eleven subjects were included into this control measurement (four gamma nail lag screws, three dynamic hip screws and three proximal femoral nail lag screws). The mean percentage of error was 1.49±1.39% (range: 0 – 3.33%).

Statistical analysis: The data collected was tabulated and analyzed using statistical software, SPSS version 15 for Windows (Chicago, Illinois). The statistical tests used were independent t-test, one-way ANOVA, and repeated measures ANOVA.

RESULTS

A total of 126 AP pelvic radiographs were reviewed. Twenty six radiographs were omitted from analysis. A hundred patients were studied (males, n= 46; median age: 56 years, range 18 - 90 years old). The mean age of females was significantly older than males (males vs. females; 42.8±24.0 years vs. 61.7±23.6 years, $p < 0.05$; Table II). Ethnically, there were 33% Malays, 33% Chinese, 28% Indians and 4% other races, reflecting the composition of the population utilizing the services provided by UMMC. These radiographs were from two main groups of patients: 45% were patients with hip fractures (intertrochanteric fracture, subtrochanteric fracture or fracture neck of femur), and the remainder were patients who had pelvic x-rays for reasons other than hip fractures (screening pelvic x-ray in patients with lower limb fractures, dislocations of the hip joint, osteoarthritis of the hip joint and others).

The mean NSA, NW, NW130 and NW135 are tabulated in Table II. The NW was statistically wider in males than in females (36.2 ± 3.2 mm vs. 32.0±2.8 mm; $P<0.001$). There was no difference noted for NSA between gender ($p = 0.911$).

Table II shows the mean NSA and NW between various races. Indian patients generally had narrower NW (mean = 33.4±3.8 mm) amongst the various races but this was not statistically significant. There were discrepancies noted in the mean age between various races.

Looking into the box plot (Fig. 2) of NW, NW130 and NW135, all of these factors had approximately normal distribution and almost similar variability. The error bar (Fig. 3) showed that there was considerable overlap in the 95% confidence interval between all factors. This suggested little difference between them. We used the repeated measures ANOVA to analyze the relationship between NW, NW130, and NW135 for the patients. There was no significance difference between the measurements of width in NW, NW130 and NW135 ($P = 0.998$). (Table IV)

Only a female patient (1% of the sample population) had NW narrower than 25.0 mm and three female patients (3% of the sample population) had NW narrower than 27.5 mm. Fifteen percent of the sample population had NW less than 30.0mm. None of the patients had NW130 narrower than 25.0 mm, four females (4% of the sample population) had NW130 narrower than 27.5 mm and 18% of the sample population had NW130 narrower than 30.0 mm. A female patient (1% of the sample population) had NW135 narrower than 25.0 mm, four females had NW135 narrower than 27.5 mm and 15% of the sample population had NW135 narrower than 30.0 mm. All male patients had NW, NW130 and NW135 more than 27.5 mm. (Table V)

Table I: Definitions used in the present study

Neck shaft angle (NSA)	The angle between axis of the femoral neck and the axis of the shaft of the femur.
Neck width (NW)	The shortest distance within the femoral neck perpendicular to the femoral neck axis.
Neck width at 130° (NW130)	The shortest distance within the femoral neck perpendicular to the line 130° from the femoral shaft axis.
Neck width at 135° (NW135)	The shortest distance within the femoral neck perpendicular to the 135° from the femoral shaft axis.

Table II: Descriptive Statistics by Gender

Variable	Male (n=46)		Female (n=54)		Total (n=100)	
	Mean±S.D	Range	Mean±S.D	Range	Mean±S.D	Range
Age (years)	42.8±24.0	18-90	61.7±23.6	18-88	53.0±25.5	18-90
NSA (degrees)	135.9±5.8*	124.0-152.0	136.0±5.6*	123.0-148.0	136.0±5.6	123.0-152.0
NW (mm)	36.2±3.2**	29.5-43.0	32.0±2.8**	24.6-37.8	34.0±3.7	24.6-43.0
NW130 (mm)	36.3±3.4**	28.6-44.0	32.0±3.1**	25.3-38.1	34.0±3.9	25.3-44.0
NW135 (mm)	36.3±3.3**	28.6-42-6	32.0±3.0**	24.9-37.8	34.0±3.8	24.9-42.6

* p = 0.911 (comparing between male and female)
** p < 0.001 (comparing between male and female)

Table III: Descriptive Statistics by Ethnicity*

Variable	Malay (n=33)		Chinese (n=33)		Indian (n=28)	
	Mean±S.D	Range	Mean±S.D	Range	Mean±S.D	Range
Age (years)	35.3±18.6	18-78	72.0±16.8	21-90	53.8±25.3	18-89
NSA (degrees)	135.8±5.4	123.0-145.0	136.4±5.5	127.0-148.0	135.8±6.4	124.0-152.0
NW (mm)	34.3±3.8	27.1-42.2	34.0±3.5	27.0-43.0	33.4±3.8	24.6-40.6
NW130 (mm)	34.0±34.0	26.9-42.4	34.3±3.8	27.0-44.0	33.4±4.0	25.3-41.4
NW135 (mm)	34.2±3.8	27.2-41.8	34.1±3.7	27.3-42.6	33.4±4.1	24.9-42.5

* Race category 'other races (n=4)' was omitted

Table IV: Pairwise comparisons between NW, NW130 and NW135

(I) Width (mm)	(J) Width (mm)	(I-J) Mean difference (mm)	Std. Error Mean	Sig.**	95% Confidence interval for Difference**	
					Lower Bound	Upper Bound
NW	NW130	-0.004*	0.1146	0.972	-0.2315	0.2235
	NW135	-0.005*	0.0937	0.958	-0.1910	0.1810
NW130	NW	0.004*	0.1146	0.972	-0.2235	0.2315
	NW135	-0.010*	0.1019	0.992	-0.2031	0.2011
NW135	NW	0.005*	0.0937	0.958	-0.1810	0.1910
	NW130	0.010*	0.1019	0.992	-0.2011	0.2031

Based on estimated marginal means.
* The mean difference is not significant at the 0.05 level.
** Adjustment for multiple comparisons: Bonferroni. (0.05/3=0.0167)

Table V: Percentage of patients with NW, NW130 and NW135 less than 25.0mm, 27.5mm and 30.0mm respectively

		Percentage (%)		
		Male (n=46)	Female (n=54)	Total (n=100)
NW	≤ 25.0mm	0	1.9	1.0
	≤ 27.5mm	0	5.6	3.0
	≤ 30.0mm	4.3	24.1	15.0
NW130	≤ 25.0mm	0	0	0
	≤ 27.5mm	0	7.4	4.0
	≤ 30.0mm	4.3	29.6	18.0
NW135	≤ 25.0mm	0	1.9	1.0
	≤ 27.5mm	0	7.4	4.0
	≤ 30.0mm	2.2	25.9	15.0

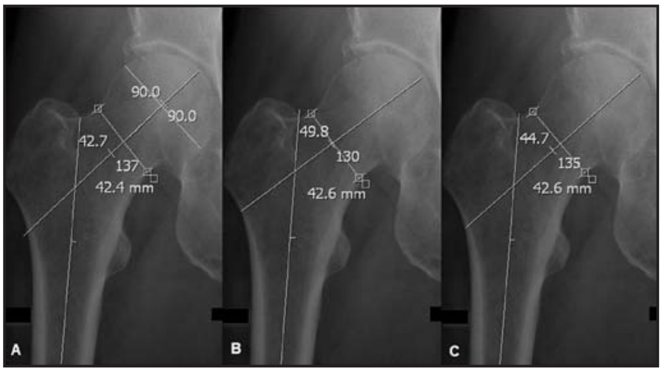

Fig. 1: Measurement of NSA, NW, NW130 and NW135 using IMPAX software. An example of measurement that was recorded: A: NSA = 137°, NW = 42.4mm. B: NW130 = 42.6mm. C: NW135 = 42.6mm

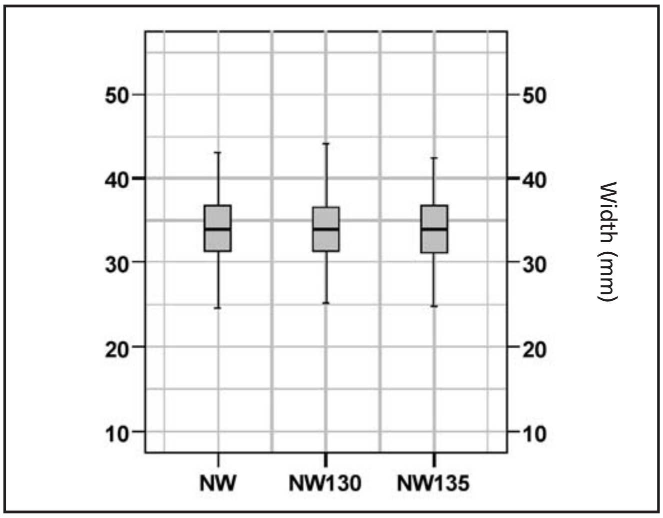

Fig. 2: Box plot for NW, NW130 and NW135

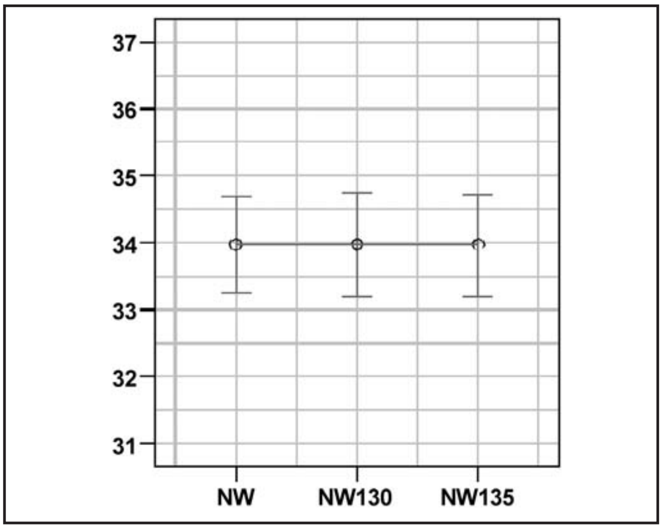

Fig. 3: Error bar for NW, NW130 and NW135.

DISCUSSION

The proximal femoral geometry had been studied in relation to osteoporosis especially amongst postmenopausal women with hip fractures. Studies had suggested that the proximal femoral geometry indeed influenced the risk of hip fracture [7,8,9]. For this purpose, various parameters, including the neck-shaft angle (NSA) and femoral neck width (NW), were assessed. Evidence has shown that NSA can be used together with bone marrow density measurement to predict the risk of hip fractures [10,11,12]. Others had found that NW can also influence the prediction for the occurrence of fracture [13,14].

In a recent report, Karasik *et al.* had studied dual energy absorptiometric scans of the proximal femur from 1473 members in 323 pedigrees (divided into original and offspring in the analysis) in the Framingham Osteoporosis Study[15]. By far this study had the largest pool of patients in which femoral geometry measurements were recorded and evaluated. The result for the mean NSA for the original male subjects (n=346) was 131.4±6.5° and the male offspring (n=490) was 130.6±5.7° whereas for the original female subjects (n=592) was 128.1±6.1° and the female offspring (n=597) was 127.9±5.9°. The mean outer diameter of narrow neck in the original male subjects was 3.4±0.3cm and the male offspring was 3.3±0.3cm whereas the result for the original female subjects was 2.9±0.3cm and the female offspring was 2.8±0.2cm.

Other studies in Europe [16,17], Africa [18] and Asia [19] showed somewhat variable NSA (121.0°-132.1°) and NW (33.1-38.0 mm) measurement. Some had shown that the femoral geometry differed in gender[17] indicating that the female population had a narrower femoral neck and smaller NSA. Cadaveric studies had attempted to compare Asian proximal femoral geometry with the Caucasian population[20,21]. Two studies had described and reported that femoral neck width for Asians (Hong Kong Chinese[20] and Thai[21]) were comparatively smaller than that of a Caucasian. However, no statistical analysis was done to test the significance of these values.

Various implants had been devised for the fixation of hip and proximal femoral fractures. Most of these implants were initially designed based on measurements in Caucasian population. These implants are being used for the Asian population. This posed a possible problem of mismatch in the sizes of implant for the Asian population[22].

There are a few different types of intramedullary proximal femoral nail systems available for fixation of intertrochanteric and subtrochanteric fractures. Most systems consist of an intramedullary femoral nail, a femoral neck screw or lag screw and distal femoral shaft locking screws. Some systems (e.g. PFN) employ an anti-rotational pin or hip pin fixation into the femoral neck adjacent to the femoral neck screw to give additional rotational stability. This configuration of fixation had shown to give better biomechanical stability in certain types of intertrochanteric fracture especially the reverse obliquity variant, as compared to the single femoral neck screw nails, such as the Gamma nail[23].

In this study, true AP pelvic radiographs were chosen to provide the measurements of NSA, NW, NW130 and NW135. Pelvic radiographs are usually taken in patients with proximal femoral fractures. Preoperative planning is commonly done using plain radiographs including the pelvic film. Rarely, 3D assessment of a fracture is needed prior to fixation. Moreover, preoperative templating is usually done on plain pelvic radiographs. Error in measurements due to anteversion or retroversion of the femur can be minimized by the inclusion of only true AP pelvic projections. Thus, the assessment of the true AP pelvic radiographs can be both practical and reasonably accurate.

We found that the femoral neck width in our sample population was adequate for placement of femoral neck screw and anti-rotation pin using the PFN implant. (Mean NW = 34.0±3.7mm, min = 24.6mm). Even though the female population had smaller neck width (mean = 32.0±2.8mm) than males, it was still within an acceptable size for a femoral neck screw and an anti-rotation pin placement. The distance between the upper border of the anti-rotation pin and the lower border of the femoral neck screw is approximately 20 mm. In our experience, the margin of safety for placement of both the femoral neck screw and anti-rotational pin is approximately 5mm (2.5mm cranially and 2.5mm caudally). Thus, placement of both the screw and pin will be difficult in those with femoral neck width less than 25mm. In this study, only a female patient had NW less than 25.0mm, none had NW130 less than 25.0mm and a female patient had NW135 less than 25.0mm. Ninety seven percent of the study population had NW more than 27.5mm and 75% had neck width more than 30.0mm. All the male patients had NW, NW130 and NW 135 more than 27.5mm. (Table V)

In respect to the changes in neck width working area in relation to the implant neck screw angle (130° and 135°), there was no significant difference. There was no difference between femoral neck width working area for both the 130° and 135° angle implants in our sample population. (Table IV) Therefore, femoral neck screws and hip pins can be inserted at these prefix implant angles without any worry to the variance of the femoral neck width.

The discrepancies in mean age noted between gender (Table II) and also ethic (Table III) can be explained by inferring to the etiology of the fracture (motor vehicle accident vs. pathological fracture secondary to osteoporosis) and socioeconomic factors based on this study samples which reflects an urbanized Malaysian population.

In conclusion, both the femoral neck width and neck shaft angles generally were not factors influencing the placement of femoral neck lag screws and anti-rotation pin in proximal femoral nailing. However, case to case evaluation is still needed to exclude cases with extremely narrow femoral neck width, where an implant with a single femoral screw nail can be considered.

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