PROXIMAL FEMORAL GEOMETRY IN INDIANS AND ITS CLINICAL APPLICATIONS

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ABSTRACT

Fractures of the proximal femur involving the neck and trochanters are quite common. Internal fixation of these fractures with implants is mandatory for early mobilization and rehabilitation of the patients. These implants have been designed according to the dimensions of the proximal femur. These are exclusively designed according to the Western dimensions. Most of our Indian Orthopaedic surgeons have currently felt the need for modification of these dimensions to suit the Indian standards. The usage of these over-sized implants adversely affects the functional end result of the surgery. To our knowledge references about the proximal femoral dimensions including neck shaft angle, length and width of the femoral neck in the Indian literature are scarce. Therefore this study was carried out in dry bones to enlighten the Orthopaedic surgeons and Biomechanical engineers about the proximal femoral geometry. An attempt has been made to compare the obtained results with the dimensions of existing implants. 578 unpaired femora collected from the departments of Anatomy, Sri Ramachandra Medical College and Research Institute (SRMC&RI)Chennai, Vinayaka Misssions Kirupananda Variyar Medical College (VMKVMC) Salem and Madras Medical College (MMC) Chennai were used for the present study. The data regarding the dimensions of the implants were collected from the department of Orthopaedics SRMC & RI, Chennai. The neck-shaft angle, length and width of the neck of femur were studied using goniometer and vernier calipers respectively as per standard guidelines. The results were recorded and worked out statistically. The average neck shaft angle in the present study was found to be 126.55 degrees. The mean neck length was found to be 3.19 cm and the mean width was 3.1 cm. The present study concludes that the dimensions of currently available Western orthopaedic implants do not match the dimensions of the proximal femora of Indians and stresses the need for modification of the same.

Key words: Femur, Fracture, Dimensions, Implants, Geometry

INTRODUCTION

The neck of the femur in humans is an important functional modification after man attained erect bipedal posture. The angle of inclination (neck-shaft angle) has been studied by many workers including Hasimoto M (1938), HumphreyWH (1958), Kate BR (1967), Parson PG (1914) ,Singh PI (1968) and Siwach RC (2003)[1,2,3,4,5,6]. The clinical importance of neck shaft angle of femur lies in the diagnosis, treatment and follow-up of fractures of the neck of femur, trochanteric fractures, slipped upper femoral epiphysis, developmental dysplasia of the hip and neuromuscular disorders of the lower extremity. The common implants used for the surgical treatment of proximal femoral fractures include (i) Dynamic Hip Screws (DHS) (ii) ASNIS screws (iii) Cancellous screws and (iv) Blade plates. These implants are designed primarily for use in Western population, whose constitutional and biomechanical factors vary from those of Indian population. According to Siwach (2003) and Noble P.C (1988), in case of total hip arthroplasty, it is mandatory that the design and dimensions of the femoral component should match the anatomy of the femur[6,7]. Siwach (2003) had noted a geometrical discrepancy between these Western implants and our Indian femora[6]. Use of such implants in Indians increases the chances of implant failure significantly leading to non union, malunion and avascular necrosis[6]. Most of our Indian Orthopaedic surgeons have currently felt the need for modification of the dimensions of these implants to suit Indian

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standards. Review of the literature showed a dearth of information about the proximal femoral geometry (neck shaft angle, length and width of neck) in Indian population. Hence this study was carried out to analyze the proximal femoral geometry in Indian femora and compare these dimensions with the dimensions of the Western implants.

MATERIALS AND METHODS :

Five hundred and seventy eight (578) normal adult femora without any pathology obtained from the departments of Anatomy of Sri Ramachandra Medical College and Research Institute (SRMC & RI)Chennai, Vinayaka Missions Kirupananda Variyar Medical College (VMKVMC)Salem, Madras Medical College (MMC) were utilised for this study. Sex and age of the bones were not determined. Commonly used implants namely DHS, Fixed Angle Blade Plates, AO screws (Fig.1) were obtained from the department of Orthopaedics, SRMC & RI Chennai. Their dimensions were tabulated (Table I). The study was conducted during the period 2005-2009.

IMPLANT	DIMENSION
DHS /DCS	
(i) Thread diameter	12.5 mm
(ii)Thread length	22 mm
(iii)Shaft diameter	08 mm
(iv)Barrel angle	125deg. To 150deg. (Commonly used 135deg.) [18]
(v)Barrel diameter	12.6 mm
(vi)Barrel thickness	05.8 mm
(vii)Barrel width	19 mm
AO SCREWS	
(i) Thread diameter	6.5 mm
(ii)Shaft diameter	4.5 mm
BLADE PLATE	
(i) Blade length	35 mm
(ii)Blade thickness	2 mm

TABLE I: DIMENSIONS OF ORTHOPAEDIC IMPLANTS COMMONLY USED FOR TREATMENT OF PROXIMAL FEMORAL FRACTURES

The neck shaft angle of femur was determined according to the guidelines given by Singh and Bhasin (1968)[5]. The axis of the neck was determined by a coloured thread dividing the anterior surface of the neck into two equal halves[5] (Fig.2). In the mid-sagittal plane over the anterior surface, the axis of the shaft (extending from the upper end of the oblique line of the condyles) was marked using the same thread[5] (Fig.3). The angle was measured using a Goniometer. (Fig.4)

The length of the neck was measured along the long axis of the neck both anteriorly and posteriorly using vernier calipers. Anteriorly the length was measured between the base of the head and the mid-point of the intertrochanteric line (Fig.5). Posteriorly the length was measured between the base of the head and mid point of intertrochanteric crest (Fig.6). Further, the width of the neck was measured using vernier calipers at the narrowest part of the neck (Fig.7).The results were computed and analyzed statistically with SPSS 15.0

RESULTS :

The statistical analysis was done using SPSS 15.0. The descriptive statistics (frequency, range, mean and standard error) for the variables (neck-shaft angle, length of neck, width of neck) are presented in Table II. Comparison of the variables studied and the dimensions of the implants are presented in Tables III & IV.

DISCUSSION :

The neck of the femur in humans is a very important structural and functional specialization for man's erect posture. Most of the text books of Anatomy quote the average neck-shaft angle in adults as 125 degrees (range 110 deg. to 144 deg.) and in foetuses as 140 degrees8. Not many Indian studies are available with respect to the dimensions of the proximal femur. Kate (1968) worked on 1000 femora and found the average angle to be 128.4 degrees[3]. Siwach (2003) worked on 75 pairs of femora and reported the average neck shaft angle as 123.5 degrees[6]. Saikia KC (2008) has reported the average neck shaft angle in the North

VARIABLE	FREQUENCY	MEAN	RANGE	STD. ERROR	MEAN +/-2 SE
Neck shaft angle	578	126. 55 deg.	112 - 146	0.201	126.03 – 126.94
Length of neck					
Anterior (A)	578	3.009 cms	2.0 – 4.2	0.0158	2.967 – 3.0406
Posterior (P)	578	3.368 cms	2.0 – 4.8	0.0171	3.338 – 3.4022
Mean (A + P/2)		3.099 cms	--------	0.0732	3.161 – 3.2146
Width of Neck	578	3.099 cms	2.0 – 3.4	0.0732	2.950 – 3.2434

TABLE II: DESCRIPTIVE STATISTICS

VARIABLE	PRESENT STUDY	DIMENSION OF IMPLANT
Neck shaft angle	126.55 degrees	125 - 155 deg (commonly used 135 deg.)
Neck length	3.188 cms (31.8 mm)	2.2 cm (thread length)
Neck width	3.099 cms (30.99mm)	2.48 cm (Barrel diameter + thickness)

TABLE III: COMPARISON BETWEEN DIMENSIONS OF INDIAN FEMORA AND DIMENSIONS OF IMPLANTS (DYNAMIC HIP SCREWS)

VARIABLE	PRESENT STUDY	DIMENSION OF IMPLANT
Neck Width	3.099 cms (30.99 mm)	6.5 mm (Three screws are commonly used – 6.5 X 3 = 19.5 mm)

TABLE IV: COMPARISON BETWEEN DIMENSIONS OF INDIAN FEMORA AND DIMENSIONS OF IMPLANTS (AO SCREWS)

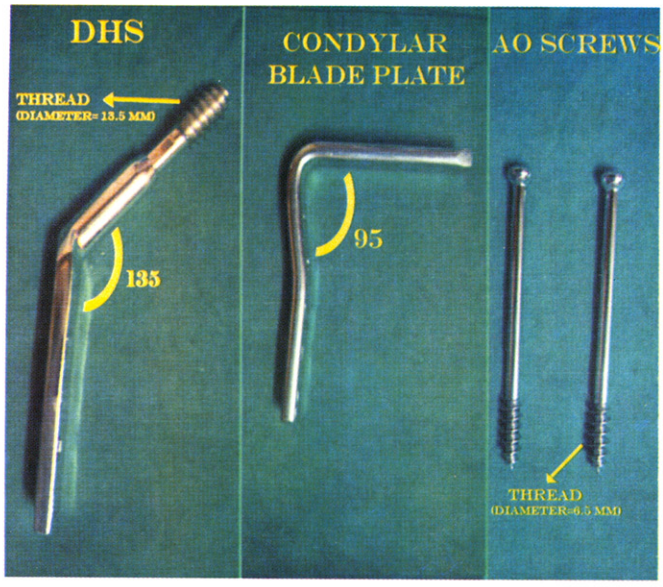

Fig.1: Common Orthopaedic Implants Used for Fixation of Proximal Femoral Fractures and their dimensions

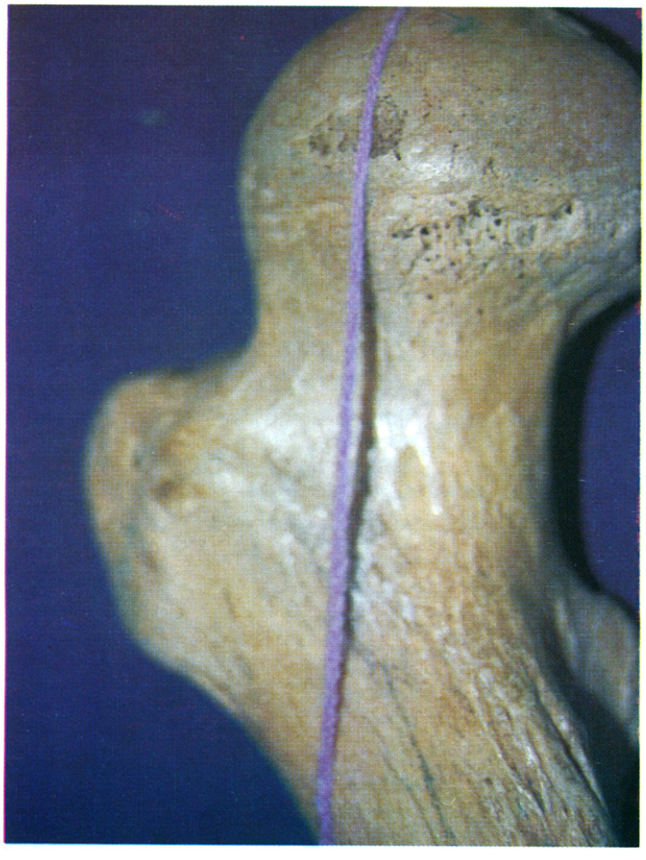

Fig. 2 Determination of Neck Axis

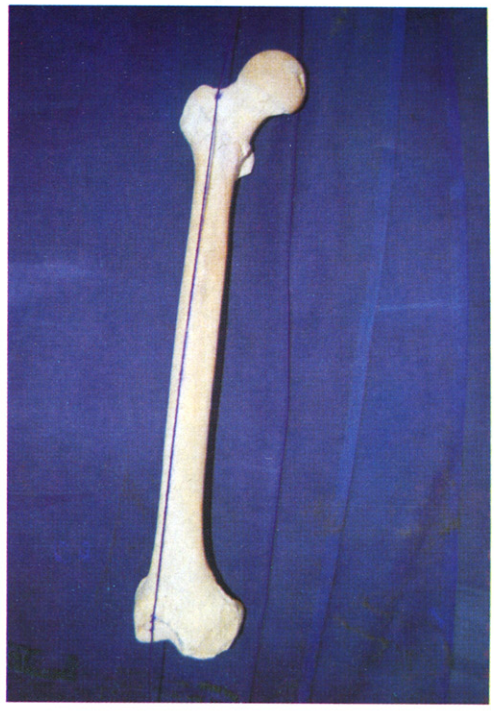

Fig. 3 Determination of shaft axis

Fig.4: Measurement of Neck shaft angle with Goniometer

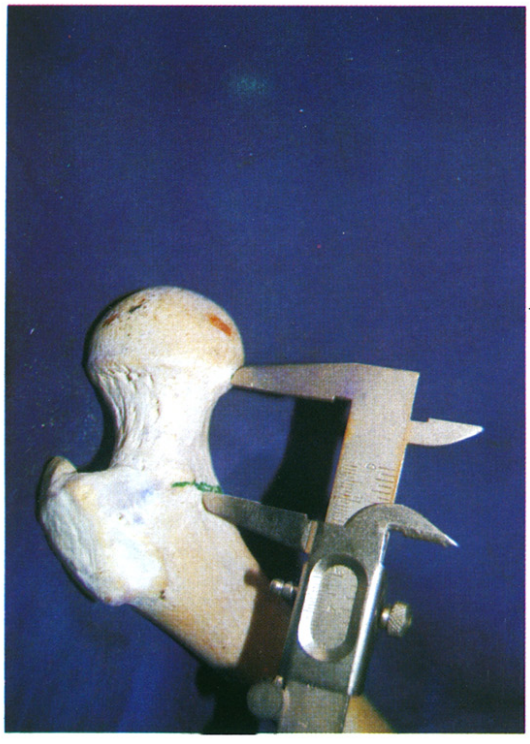

Fig. 5 Determination of anterior neck length

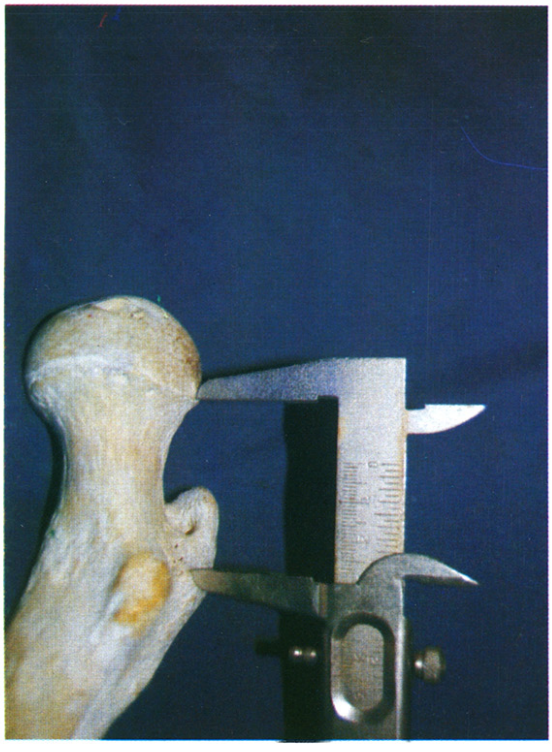

Fig. 6: Determination of posterior neck length

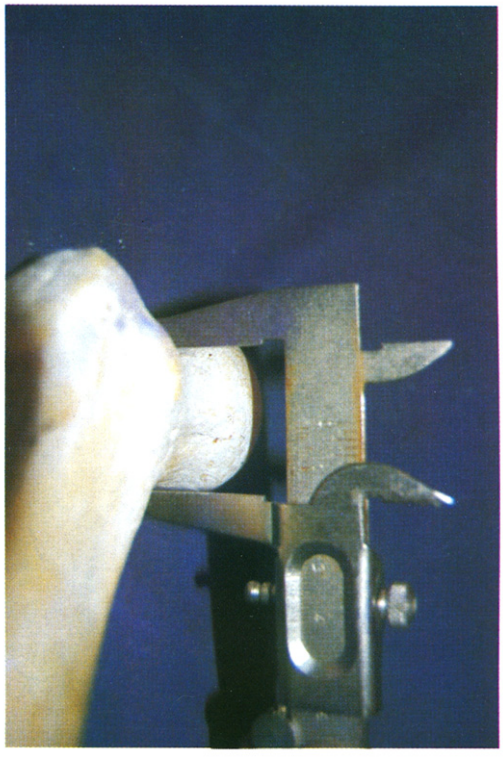

Fig. 7: Determination of neck width

Eastern population as 139.5 degrees [9]. Isaac B (1993) found the average neck shaft angle as 127.5 deg[10]. Whereas Toogood et al (2009), in their study on proximal femoral anatomy in the normal human population have reported the average angle as 129.23 deg[11]. The average angle in the present study (n= 578) is found to be 126.55 degrees (range 112 - 146), standard error being 0.201. Our results are almost similar to that of Siwach, Isaac and Toogood et al but differs largely from that of Saikia et al.

The mean neck length in the present study is 3.188 cms and the standard error is 0.0133 whereas Siwach (2003) observed maximum effective neck length as 3.72 cms and minimum effective neck length as 2.26 cms[6].

The mean neck width in the present study is 3.097cms (S.E. 0.0732) which is more when compared with the observations of Siwach (2003) who had observed it as 2.49 cm (anteroposteriorly) and 3.18 cm (superoinferiorly)[6].

Hoaglund FT (1980) in his comparative study on the anatomy of proximal femur, found significant differences in the measurements of the head, neck, and proximal femoral shaft of average normal Caucasians and Hong Kong Chinese people. According to him the average neck -shaft angle of Caucasians is 135 degrees and ante version angle is 8 degrees [12]. Kate (1967) found the Formosans to have

lowest average neck shaft angle (125.6 deg.) and Andamanians the highest angle(134 deg.)[3]. He also found a difference in the angle between various races of India. He found the largest angle (133 deg) from Madurai (South India) and the smallest average angle (122 deg.) from Bombay. Saikia KC (2008) has observed variations of neck shaft angle between the North Eastern population (Mongoloids) and Caucasians[9]. Chauhan et al (2002) concluded that the variations in the parameters of the proximal femur and acetabulum were insignificant among the different populations in India but the data of two different countries (race) varied significantly13. Thus it is clear that the proximal femoral geometry varies among different ethnic groups. Therefore usage of implants designed exclusively for Western bones will not be suitable for other ethnic groups.

A comparison between the dimensions found in our study and the dimensions of the available Orthopaedic implants (Table III & IV) shows that these implants are oversized for the Indian skeleton and sufficient bone stock is not available for an effective fixation. Use of such implants not only affects the functional end result of surgery but also negates the very purpose of internal fixation and an early rehabilitation.

The Dynamic Hip Screw (DHS) is the implant of choice for stable trochanteric fractures & Dynamic Condylar Screw (DCS) / Condylar Blade is the implant of choice for unstable trochanteric fractures[14,15].

Higher angle implants (eg. DHS barrel angle: 135 degrees) causes malunion in valgus & that with lower angle (DCS & Condylar Blade plate 95 degrees) causes malunion in varus thus altering the biomechanics both at hip and knee joint posing the patients to a greater risk of secondary arthritis at a later date.

Insertion of these screws needs reaming thus removing the available cancellous bone. Screws with large thread diameter occupy greater area in the neck and head of the femur. Such a large area drilled in the neck of Indian femora takes away viable cancellous bone. To quote an example, the thread diameter of the DHS / DCS is 12.5 mm and barrel diameter is 12.6 mm (Table I). Insertion of this screw needs reaming up to 11.5 mm (i.e. 1.15 cm) and tapping up to 13.5 mm (i.e. 1.35 cm). This removes a large cancellous bone stock cylinder from the neck. Siwach (2003) had observed the neck width as 2.49 cm (AP) and 3.18cm (supero-inferiorly)[6]. The width of the neck in our study is only 3.097 cm. Therefore it is clear that these implants would occupy most of the available space in the neck and would cause tamponade effect resulting in non-union and avascular necrosis[6].

Mishra AK et al (2009) in their study on a second look at rational of implant design for the proximal femur have concluded that the Western implants should be used only after careful consideration in Indians. He also stresses that the fracture implant designs should be specific for Indian bones[17].

In case of total hip replacement surgeries, anterior thigh pain, aseptic loosening (Reddy et al,1999)[16] intraoperative splintering and fractures are common complications because of oversized femoral components particularly in uncemented versions[6,16].

CONCLUSION:

The results of the present study shows that the Indian dimensions of the proximal femur are obviously lesser than the Western standards. The dimensions of the currently available Orthopaedic implants do not match the dimensions of the Indian femora. Therefore this study will enlighten the biomechanical engineers to take a revolutionary step towards altering the implant designs to suit our Indian needs and thus change the concept of Orthopaedic surgeries in our country. Gender and age of the bones has not been taken into account in the present study warranting inclusion of these parameters in future

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