The proximal femur –a second look at rational of implant design

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ABSTRACT

Twenty five pairs (50 bones) of cadaveric femora were studied morphologically and radio logically using standardized techniques to obtain anthropometric data to evaluate the applicability of internationally designed implant and to generate a database for proximal femur to help in design for future implant if these were found unsuitable. Measurements : femoral head diameter , femoral neck diameter , diameter of proximal femur, canal width at above and below lesser trochanter and 7.5 cm below lower margin of lesser trochanter, endosteal and extracortical width, isthmus position from lesser trochanter, femoral neck anteversion, neck shaft angle and intramedullary axis of femur. The mean +_ SD of these values were calculated. These values were compared with those reported in the literature for Hong Kong Chinese, Caucasians and were found to be different. The implant designed for western population should be used judiciously and facture implant designed should be specific for (ours) bones . We found the pyriformis fossa is usually not in line with the intramedullary axis. Thus antegrade itramedullary nailing portal should be anterior and lateral to pyriformis fossa.

Keyword: Proximal end femur, anthropometric measurements, western versus ours standard, intramedullary axis of femur.

INTRODUCTION

The proximal end of femur has been the subject of much attention for orthopedic surgeons as operation on proximal femur are one of commonest in orthopedic surgical practice.[1] The proximal femur in human is subjected to large variety and a magnitude of force during day to day activities. The aim of this operation is to remove pathology and restore anatomy to normal as far as possible. Thus the basic purpose of this study is to accumulate data on people of developing countries like ours, who's built, physique, habits, genetic makeup and personal life styles are different from western civilization. While data base regarding anthropometry of proximal femur is available for western population.[2,3] The same can not be said for native Nepalese population. So to minimize intra operative and postoperative complications, the implants should be designed by taking in to account anthropometry and biomechanics data.[1-5] Thus the study conducted with aim to remove lacuna of information about proximal femoral geometry in Nepalese people and evaluate its impact on implant design and establish the entry portal for antegrde intramedullary nailing during surgery.[4-6]

MATERIALS AND METHODS

The study was conducted on 50 adults' cadaveric femora. Specimens that showed osseous pathology or previous fracture were excluded from the study. These femora were differentiated into male and female . The study included femora of adult group only.

Roentgenogram of 50 specimen were taken in to anteroposterior and end axial view using standardized technique. The specimen was placed directly over the cassette so that the magnification would be insignificant. The distance between the X-ray source and the film was 90 cm and beam was centered on lesser torchanter with femur lying in neutral rotation. For end axial view, X-ray beam was projected through condyles parallel to long axis of proximal shaft of femur so that condyles, head and neck were projected on film with Plates kept at femur head.To measure this the femur was kept on translucent box with trochanter and both femoral condyles touching the surface-ray cassette was kept touching the femoral head with manually holding the cassette after wearing lead apron. Ray was projected through condyel to long axis of porximalshaft of femura so the condyles head and neck projected on the film and anteversion was measured.[7-9]

To determine the intramedullary axis of femur the cadaver femur was cut in transverse plane 10 cm below the lesser trochanter. A hollow tubular rod of appropriate size of medullary cavity was inserted into canal without reaming. Then retrograde drilling of femur with long straight rod with pointed tip was done to exit at upper end to establish the relationship of intramedullary axis of femur with anatomical landmarks of proximal femur.

MORPHOLOGICAL STUDY

The standard extracortical and endosteal dimensions were determined by direct measurement of cadaveric

Table-1: Morphological measurements

Dimension(n=50)	Average (mm)	Minimum (mm)	Maximum (mm)	Standard deviation
Femoral head diameter	42.9	35	48	3.53
Femoral neck diameter (superoinferior) . Subcapital	33.28	25	41	3.22
.Transcervical	30.52	22	38	3.48
.Basal	39.48	25	48	4.80
Femoral shaft diameter .Just above LT	40.18	31	49	4.24
.Just below LT	30.12	24	37	2.87
.7.5 cm below LT	25.50	20	35	29.7

specimens. These measurements were done with the help of template, vernier caliper and goniometer.

The femoral head diameter was measured with template and with help of vernier caliper, femoral neck diameter at (subcapital, Tran cervical, and basal region) femoral shaft diameter just above and just below lesser trochanter and 7.5 cm below lesser trochanter was measured.

RADIOLOGICAL STUDY

With help of scale we measured the femoral head diameter, neck diameter, canal width just above and below the lesser trochanter, 7.5 cm below the lesser trochanter, and endosteal width at isthmus and isthemic position in relation to lesser trochanter. With the help of goniometer, neck shaft angle was measured.

To establish the intramedullary axis of femur, the distance between the tip of the rod and center of pyriformis fossa was measured with caliper and it's exist in relation to pyriformis fossa was noted.

RESULTS

The average values of the morphological parameters studied, their standard deviation, minimum and maximum values compared with western and Asian (Hong Kong Chinese) is depicted in table 1. Table 2 measures the radiological aspect of all the morphological measurement. Table 3 represents the comparison of femoral neck ante version in various ethnic groups.

The relationship of intramedullary axis and anatomical landmarks of proximal femur revealed that the femoral canal axis lies anterior and lateral to pyriformis fossa.

DISCUSSION

The orthopedic implants are considered universally applicable to all skeletons, irrespective of the differences among various ethnic groups. Although different size of same design generally are available from manufactures, there is little evidence that ethnic morphologic difference are taken into account in orthopedic implant design.[1,10] This universal application may not cause major clinical problems in implants that are applied externally to the skeleton; however, problems do arise with implants that are applied internally to skeleton. This becomes obvious in Intra medullary fixation of fracture and hip prosthesis, where linear and angular configuration has to be considered.[1,11,12] The implant device and prosthesis designed for western skeleton are large in size, there angles, orientations and thread length also mismatch the femora. To get rid of this problem is to fit the prosthesis or implants by removing more bone which decreases bone stock, increasing the risk of intra operative fractures and post operative complications. Implants that are designed by taking in to account anthropometric and bio mechanic data will help in designing patient specific implants there by minimizing the complications.

As is evident from perusal of table1, there is appreciable difference of femora from other ethnic groups.[2,3] The average femoral head is smaller than western value. The trans cervical region of neck is the narrowest portion of

Table-2: Radiological measurements (n=50)

Dimension(n=50)	Average (mm)	Minimum (mm)	Maximum (mm)	Standard SD	Western	Asian
Femoral head diameter	44.26	36	50	3.58	46.1	45
Femoral neck diameter (superoinferior)	34.42	26	42	3.30	45.4	31
.Subcapital	31.92	23	39	3.44	29.4	
.Transcervial Basal	41.76	28	49	4.58		
Femoral shaft diameter .just above LT	41.08	32	51	4.39		
.just below LT	30.94	24	38	2.89		
.7.5 cm below LT	25.98	20	32	2.75		
Extracortical width at isthmus (medio-lateral)	25.48	20	31	2.62		
Endosteal width at Isthmus (Medio-lateral)	10.02	8	15	1.49	12.3	
Isthmus position	101.01	60	160	18.57	113.4	
Neck-shaft Angel	132.260	1180	1500	8.360	124.70	1350

Table-3: Anteversion

Different studies	No.	Average	Standard deviation	Minimum	Maximum
Caucasian					
Male	112	7*		2*	35*
Female	31	10*		2*	25*
Asian					
Male	116	14*		4*	36*
Female	35	16*		7*	28*
Our study					
Male	34	15.41*	5.21	9*	26*
Female	16	15.12*	3.97	9*	26*

femoral neck. This is of particular importance while fixing the fracture neck femur with screw as large diameter screw may decancellate the neck to very large extent there by metal may ensue temponade effect and can cause the a vascular necrosis of head, consequently resulting in non union of fracture neck or a vascular necrosis.

Since our heads are smaller the threads of a screw often fail to cross the fracture neck of the femora specially if the fracture is sub capital and screw placement is in inferior quadrant of head. Thus we must have screw with shorter thread length.

The availability of geometry data describing the proximal femur allows guidelines to be developed for the functional dimension of femoral component. These anatomic data also allow assessment of the match between the shape of existing components and the proximal femur.[11-13] Numerous published studies have underlined the importance of a close fit between the femur and the implanted stem. Femoral stems are expected to occupy 80% of cross section of medullary cannel. In cemented prosthesis the optimal cement mental is 4 mm proximally and 2 mm distally. It has been noted that there is an increase in the clinical out come in a score which was directly proportional to the degree of implant bone fit. A strong co relation has also been established between the occurrence of anterior thigh pain and inadequate fit and fixation of implant. The clinical symptoms of bone implant mismatch are due to micro motion which occurs between the bone and the implant. Experimental studies have shown that this micro motion should be reduced) to 14 micro or less to have bone in growth in to porous implant surface. An implant mis match may lead to micro motion of grater magnitude which manifest as aseptic loosening ,anterior thigh pain and loss of implant life. Numerous studies have also shown that there is increase in the rate of intra operative complication in the event of using mis matched implants. Especially over size implants.[1]

Concerning the most appropriate proximal entry site for intra medullary rod, the exist site for the devises tested following retrograde passage indicate that the tip of greater trochanter is not the most natural site of entry nor the pyriformis fossa.[4-6] The most appropriate area for proximal access in to the medullary canal is the junction of femoral neck and greater trochanter slightly anterior and lateral to the pyriformis fossa. Penetration through this site will benefit in terms of avoiding stress riser on superior femoral neck. The complications which occur during anti grade nailing as fracture of lateral cortex, jamming of nail, iatrogenic fracture shaft femur, failed distal locking, displacement of fracture can be over come by being in line of axis of canne.[l,5,10] This is of particular importance while reaming in old geriatric patient whose bones are osteoporotic where chances of post operative shaft fracture distal to nail is more.

This study show that the femoral canal axis lies 7.54 +-.096 mm anterior and lateral to pyriformis fossa.

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