

Morphological Cortical Index (MCI), Canal-calcar Ratio (CCR), Canal Flare Index (CFI) and Canal Bone Ratio (CBR) of proximal femur in Punjab

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ABSTRACT

Background: Preoperative assessment by calculating the morphological cortical Index (MCI), canal-calcar ratio (CCR), canal flare index (CFI) and canal bone ratio (CBR) will facilitate appropriate surgical planning for total hip arthroplasty. Since no data on indices and ratios of proximal femur in Punjab is available the study was planned to record the same from radiographs of normal adult population.

Study design: Cross-sectional population study

Methods: MCI, CCR, CFI and CBR were calculated from measurements on anteroposterior radiographs of the proximal femur from 116 male and 96 female subjects with a mean age of 46 years.

Results: Morphologic cortical index, canal calcar ratio and canal flare index did not have any statistically significant difference between the two sexes. Canal bone ratio showed a highly significant difference when the male and female group were compared ($p = 0.0042$).

Conclusion: The study has provided baseline data on morphologic cortical index, canal calcar ratio, canal flare index and canal bone ratio of proximal femur in Punjab which may be helpful in surgical planning for total hip arthroplasty and further research in the area.

Keywords: Morphological Cortical Index (MCI), Canal-calcar Ratio (CCR), Canal Flare Index (CFI), Canal Bone Ratio (CBR), proximal femur, morphometry, total hip arthroplasty (THA)

INTRODUCTION

Due to their commendable survival and low complication rate total hip arthroplasties (THA) are in vogue in management of degenerative hip disease¹. Cementless THAs are more popular and preferred over cemented implants due to their biologic bone fixation and long term stability². However increased risk of intraoperative and postoperative periprosthetic fractures as compared to the cemented prosthesis have been reported^{3,4}. In order to mitigate the threat a preoperative keen look at the specific geometrical design of proximal femur of the patient is imperative. The usual method employed in this regard is by making observations of various parameters on anteroposterior radiographs of proximal femur. Making prior assessment by calculating the morphological cortical Index (MCI), canal-calcar ratio (CCR), canal flare index (CFI) and canal bone ratio (CBR), which are dependable parameters in this regard, will facilitate appropriate surgical planning.

Skeletal features of a population group are specific depending upon its genetic makeup, geographic location and socioeconomic status⁵. No data on indices and ratios of proximal femur in Punjab being available we planned to record the same from radiographs of normal adult male and female population.

MATERIAL AND METHODS

This prospective cross sectional population study was conducted at M. Islam Medical College and Teaching Hospital, Gujranwala over a period of eight months starting September 2020 after obtaining ethical approval and subject consent. Subjects with previous history of surgery or bony affection in the region were excluded. Observations were recorded from two hundred and twelve anteroposterior radiographs with a clear image of the proximal femur from 116 male and 96 female subjects with a mean age of 46 ± 9.7 years (24 to 62).

Received on 27-07-2021

Accepted on 11-12-2021

The scheme of measurements is shown in figure 1.



Figure 1 showing the method of measurements on anteroposterior radiographs of proximal femur. Reference line X was drawn at the level of tip of lesser trochanter transverse to line Y which indicated the long axis of the shaft. Bold lines indicate widths. A: Width of canal 2 cm above the lesser trochanter B: Outer width at the level of lesser trochanter C: Internal width at the level of lesser trochanter D: Internal width at 7 cm below the reference line X. E: Outer width at 10 cm below the reference line X. F: Internal width at 10 cm below the reference line X.

Indices and ratios were defined and calculated adapted from Nam et al⁶ as follows:

Morphologic cortical index (MCI): Outer width at the level of lesser trochanter divided by internal width at 7 cm below the reference line X i.e., B/D (Fig 1.)

Canal calcar ratio (CCR): Internal width at 10 cm below the reference line X divided by internal width at the level of lesser trochanter i.e., F/C

Canal flare index (CFI): Width at 2 cm proximal to the lesser trochanter divided by Internal width at 10 cm below the reference line X i.e., A/F

Canal bone ratio (CBR): Internal width at 10 cm below the reference line X divided by outer width at 10 cm below the reference line X i.e., F/E

All measurements were taken by one investigator (FI) and reviewed independently by another observer (MSA). Results were

tabulated and means drawn; student t-test was used for significance at 95% CL.

RESULTS

Mean values \pm SD of internal and external widths taken at various levels of proximal femur in the male and female subjects are given in Table 1. Table 2 shows values of indices and ratios, their comparison in the two sexes and significance of comparison. Morphologic cortical index, canal calcar ratio and canal flare index did not have any statistically significant difference between the two sexes. Canal bone ratio showed a highly significant difference when the male and female group were compared.

Table 1: Mean \pm SD of values of various widths of proximal femur. Letters A to F refer to Fig 1.

Width		Mean \pm SD
A: Width of canal 2 cm proximal to lesser trochanter	Male	47.2 \pm 4.83
	Female	46.1 \pm 6.31
	Overall	46.8 \pm 4.95
B: External width at the level of tip of lesser trochanter	Male	42.6 \pm 3.92
	Female	40.2 \pm 4.41
	Overall	42.1 \pm 3.74
C: Internal width at the level of lesser trochanter	Male	30.2 \pm 5.21
	Female	28.3 \pm 4.93
	Overall	28.9 \pm 3.72
D: Internal width at 7 cm below the reference line X	Male	14.7 \pm 2.87
	Female	14.1 \pm 3.41
	Overall	14.6 \pm 2.94
E: External width at 10 cm below the reference line X	Male	31.5 \pm 3.10
	Female	29.7 \pm 2.85
	Overall	30.2 \pm 2.77
F: Internal width at 10 cm below the reference line X	Male	13.2 \pm 2.63
	Female	12.6 \pm 2.97
	Overall	12.7 \pm 2.65

Table 2: Mean \pm SD of values of indices and ratios in the male and female subjects and their statistical comparison

Parameters		Mean \pm SD	P value Male vs Female
CI Morphologic cortical index B/D	Male	2.89 \pm 0.43	0.4738
	Female	2.85 \pm 0.37	
	Overall	2.88 \pm 0.41	
CCR Canal calcar ratio F/C	Male	0.43 \pm 0.04	0.1939
	Female	0.44 \pm 0.07	
	Overall	0.43 \pm 0.06	
CFI Canal flare index A/F	Male	3.57 \pm 0.72	0.4099
	Female	3.49 \pm 0.68	
	Overall	3.68 \pm 0.61	
CBR Canal bone ratio F/E	Male	0.41 \pm 0.02	0.0042*
	Female	0.42 \pm 0.03	
	Overall	0.42 \pm 0.03	

*Highly significant

DISCUSSION

Cementless femoral prostheses designs are the most commonly practiced mode of fixation these days². Appropriate preoperative surgical planning by diligently templating the proximal femur and its geometrical peculiarities on radiographs of the patient may help mitigate the risk of acute postoperative periprosthetic fracture and assist in selection of appropriate prosthesis with the promise of better fixation and longevity of the implant in cementless total hip arthroplasty. The value of indices and ratios of proximal femur in this regard cannot be emphasized more.

In our study the morphologic cortical index, canal calcar ratio and canal flare index did not have any statistically significant difference between the two sexes. Canal bone ratio however showed a highly significant difference when the male and female group were compared. The overall values of indices and ratios in our study are in agreement with those reported by Bigart et al⁷ and recorded in a Caucasian population; they did not make separate

observations in male and female subjects in their study. Umar et al⁸ have recorded MCI and CFI in Pakistani population; they did not mention the exact location of sample collection. In their study the value of MCI is close to the value in our study whereas the value of CFI (4.47 \pm 0.93 vs 3.68 \pm 0.61) is noticeably higher. This may be due to regional variation in skeletal morphology.

Gender differences in various bony affections of hip have been reported in several clinical and epidemiological studies which may imply the difference in their geometrical design⁹⁻¹². The indices and ratios of proximal femur also have a predictive value for bone strength and its geometry, presence of osteoporosis, risk of fracture and mortality risk after fracture^{13,14}.

The strength of the study is that it is the first report to provide baseline reference data on such vital parameters of proximal femur as morphologic cortical index, canal calcar ratio, canal flare index and canal bone ratio in Punjab in normal adult male and female subjects which can be helpful in surgical planning.

Notwithstanding the fact that every effort was made to avoid it the study has the limitation of possible rotational error of the femur while taking the radiograph. Further research with a larger sample of general population is warranted.

CONCLUSION

The study has provided baseline reference data on morphologic cortical index, canal calcar ratio, canal flare index and canal bone ratio of proximal femur in Punjab which may be helpful in surgical planning for total hip arthroplasty and further research in the area.

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