Original Article

Femoral head–neck offset in the Indian population: A CT based study

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Abstract

Background: Femoroacetabular impingement has been postulated as the important cause of primary osteoarthritis in non dysplastic hips. We postulated that the rarity of primary osteoarthritis of hip in Indian population could be attributable to morphological differences, specifically to a lower prevalence of abnormal head–neck morphology. We conducted an anthropometric study to evaluate the prevalence of abnormal head–neck offset in Indian population and to correlate it with the low prevalence of primary osteoarthrosis in the Indian population.

Materials and Methods: The computed tomography (CT) images of 85 apparently normal hips were analysed. An axial image was created parallel to the central axis of the femoral neck and passing through the center of the femoral head using coronal scout view. This image was then used to calculate alpha and beta angles and the head–neck offset ratio. The measurements were made by two independent observers on two different occasions.

Results: The prevalence of abnormal head–neck offset ratio was 11.7% and the mean alpha and beta angles were 45.6° and 40.6°, respectively. Pearson correlation coefficients for intra-observer and inter-observer agreement were, respectively, 0.84 and 0.80 for alpha angle, 0.80 and 0.77 for beta angle and 0.78 and 0.75 for head–neck offset ratio. The values were similar to those reported in the western population.

Conclusion: The differences in the prevalence of hip osteoarthritis in Indian and western populations are not attributable to variation in the prevalence of abnormal head–neck offset.

Key words: Head–neck offset, hip, osteoarthritis, CT scan

Introduction

The etiological factor for patients categorised as primary osteoarthrosis are not known in majority of the patients.[1] Various morphological and genetic factors have been implicated in the etiology of primary osteoarthritis of the hip.[2] Femoroacetabular impingement (FAI) has been postulated as the important cause of primary osteoarthritis in non-dysplastic hips.[3,4] Decreased concavity over anterior head–neck junction, leading to abnormal head–neck offset, is the most common cause of impingement.[5] Various methods have been described in the literature for quantitative assessment of femoral head–neck offset and include offset ratio and alpha and beta angles.[5,6]

Various studies have shown that primary osteoarthritis of the hip is rare amongst Indians and Asians.[7-10] We postulated that the rarity of primary osteoarthrosis of hip in Indian population could be attributable to morphological differences, specifically to a lower prevalence of abnormal head–neck offset. We conducted an anthropometric study to evaluate the prevalence of abnormal head–neck offset in Indian population and to correlate it with the low prevalence of primary osteoarthrosis in the Indian population.

Materials and Methods

We retrospectively evaluated the computed tomography (CT) images of 85 hips obtained as a part of another project. All the patients reporting to our institute with a hip fracture were included in that project and CT was performed on the contralateral hip. The ethical clearance was obtained for the project. Patients with a past history of pain, fracture,

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surgery, dysplasia or osteonecrosis in the hip to be studied were excluded from the study.

All the CT scans were loaded on the workstation and three-dimensional reconstruction was done for each patient. An axial image was created parallel to the central axis of the femoral neck and passing through the center of the femoral head using coronal scout image. This image was then used to calculate the radiological indices of femoral head–neck offset [Figure 1]. The alpha and beta angles were calculated as described by Beaule *et al*.[11] Alpha angle is the angle formed between the central axis of the femoral neck and a line drawn from the center of the femoral head to the point at which the anterior cortex of the neck exits the circle of closest fit drawn around the femoral head. Beta angle is the angle formed between the central axis of the femoral neck and a line drawn from the center of the femoral head to the point at which the posterior cortex of the neck exits the circle of closest fit drawn around the femoral head. Similar measurements were done on posterior aspect to calculate the beta angle, a quantitative estimate of the posterior head–neck offset. We also evaluated the anterior head–neck offset ratio as described by Eijer *et al*.[12] The anterior head–neck offset ratio was calculated [Figure 2]. An offset ratio of more than or equal to 0.15 was considered to be normal.

The measurements were made by two independent observers and were repeated after 2 weeks by both the investigators to curtail the error of calculation. The mean alpha angle, beta angle and head–neck offset ratio were computed for each study subject.

Statistical analysis

The distribution was assessed using Lilliefors test. Student's *t* test (two-sample *t* test) was used to compare the results between the groups as well as to compare them with the data available in literature. All *P* values less than 0.05 were considered significant. Intra-observer and inter-observer agreement were estimated using the Pearson correlation coefficient. The first reading of each observer was utilized to estimate the inter-observer agreement.

Results

The average age of the cohort was 56 years (range 40–81 years). There were 39 males and 46 females. None of the patients had clinical features or positive clinical signs for impingement. The Pearson correlation coefficients for the alpha angle, beta angle and head–neck offset ratio are shown in Table 1. The inter-observer and intra-observer reliability of CT based measurements for the parameters of FAI was found to be good.

The calculated parameters, namely, alpha angle, beta angle, head–neck offset and offset ratio, were found to be normally distributed. The mean alpha and beta angles of the cohort were 45.63° (range, 33°-60°) and 40.62° (range, 28°-54°) respectively. The mean offset and offset ratio were, respectively, 8.59 mm (range, 6-13) and 0.202 (range, 0.11-.0.31) [Table 2]. The difference in alpha angle, beta angle and offset ratio between males and females was not statistically significant ($P>0.05$).

We compared the mean alpha angle and head–neck offset

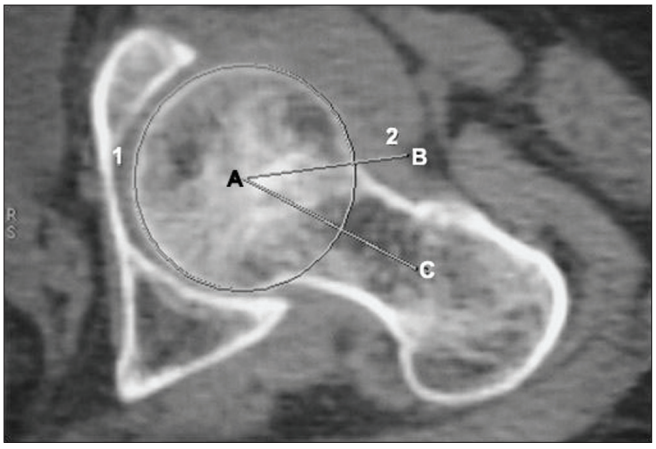

Figure 1: CT scan axial image of femoral head neck (coronal scout image) shows a circle of the closest possible fit was drawn overlaying the femoral head. The center of the circle was marked as "A." Point "B" represented a point on the anterior cortex where the edge of the anterior cortex exceeded the radius of the circle, i.e. radius of the femoral head. The line AC was drawn through the center of the femoral head and parallel to the neck axis. The alpha angle, formed between lines AB and AC, provides a quantitative estimate of the anterior head–neck offset

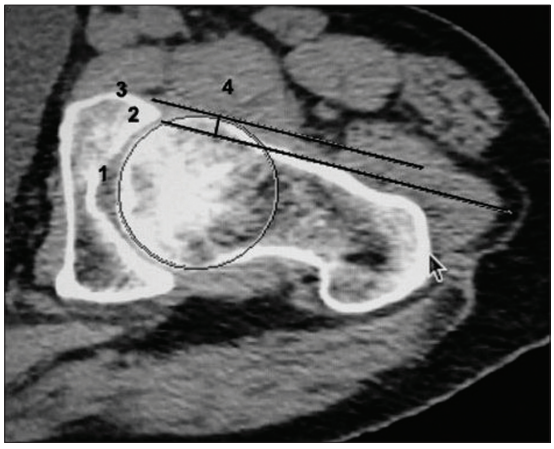

Figure 2: CT scan axial image of femoral head neck (coronal scout image) shows a circle (1) of the closest possible fit was drawn overlaying the femoral head. Line (2) was drawn parallel to the neck axis and tangential to the anterior most part of the femoral neck. A second line (3) was drawn parallel to this line and tangential to the anterior most part of femoral head. The distance between these two lines (4) would indicate the anterior offset and this distance divided by the femoral head diameter provided the head–neck offset ratio

Table 1: Reliability of measurements

	Intra-observer agreement (Pearson coefficient)	Inter-observer agreement (Pearson coefficient)
Alpha angle	0.84	0.80
Beta angle	0.80	0.77
Head–neck offset ratio	0.78	0.75

Table 2: Results of the measured parameters with standard deviations in parentheses

	Total	Males	Females
Alpha angle (SD)	45.63° (6.27°)	46.31° (5.46°)	44.93° (6.89°)
Beta angle (SD)	40.62° (5.62°)	41.44° (5.86°)	39.91° (5.36°)
Offset (SD) (in mm)	8.59 (1.73)	8.99 (1.86)	8.25 (1.55)
Offset ratio (SD)	0.202 (0.04)	0.199 (0.04)	0.205 (0.04)

Table 3: Comparison of measured parameters with historic controls of the western population

Measured parameter	Present study	Author	Value in historic controls	Significance of difference
Alpha angle	45.63°	Toogood[13]	46.61°	Not significant (*P*>0.05)
		Beaule[11]	43.8°	Not significant (*P*>0.05)
		Nozli[6]	42°	Significant (*P*<0.05)
Femoral head–neck offset ratio	0.202	Eijer[12]	0.21	Not significant (*P*>0.05)
		Clohisy[14]	0.19	Not significant (*P*>0.05)
		Pollard[15]	0.19	Not significant (*P*>0.05)

ratio in our population with historic controls from the western population [Table 3]. The mean alpha angle of our cohort, 45.63° was similar to that reported by Toogood[13] and Beaule,[11] but was significantly higher that that reported by Nozli *et al*. Ten out of 85 patients (11.8%) had a low offset ratio of less than 0.15. The head–neck offset ratio of our cohort was not significantly different from that reported by Eijer,[12] Clohisy[14] and Pollard.[15]

Discussion

Prevalence of FAI is estimated to be 10–15% in the western population and it is one of the important causes of pain in young adults.[16] In the last decade, much focus has been given to FAI being the most important cause for development of primary osteoarthrosis of hip. While primary osteoarthrosis of hip is a common condition in the western population, it is very rare in Indians. We postulated that such difference could possibly be due to a lower prevalence of abnormal head–neck offset in the Indian population. Toogood *et al.* reported on the prevalence of FAI based on a cadaveric study.[13] The other studies have compared the radiographic features of patients with features of FAI with those of control subjects.[6,11,12] Our study reports on the prevalence of radiographic features of abnormal head–neck offset in a cross section of the adult Indian population.

Of the various mechanisms described for the development of FAI, cam impingement is considered to be the most common which is caused by the decreased concavity on the anterior aspect of head–neck junction. Various authors have proposed different methods to quantify this abnormality. Of these, anterior offset ratio and alpha angles have been the most commonly studied parameters of FAI. These have been measured by various imaging modalities such as lateral radiographs, three-dimensional CT scans and magnetic resonance imaging (MRI). The Pearson coefficient for inter-observer and intra-observer variability in our study was in the range of 0.75–0.84. Thus, three-dimensional CT appears to be a reliable method to study FAI.

The mean alpha angle in our cohort (45.63°) was similar to that reported by Toogood *et al.*[13] in their cadaveric study as well as to that reported by Beaule *et al.*[11] in control subjects. Thus, contrary to our expectations, the average alpha angle reported in our study was similar to that reported in the Western population. However, the mean alpha angle in our cohort was lower than that reported by Nozli *et al.* in control subjects and the difference was statistically significant. This was probably due to difference in the nature of the cohorts. Ours was a cohort with no known hip pathology but could have included patients with FAI, while Nozli *et al.*'s[6] control group excluded patients with FAI. Interestingly, unlike the above studies, the difference in alpha angle between males and females of our cohort was not statistically significant.

Pollard *et al.* have described the reference intervals of anterior head–neck offset and ratio in normal hips of general population.[15] Append to it, there are studies comparing the offset ratios of patients having clinical features of FAI to those of control subjects.[12,17] According to these studies, an offset ratio of less than 0.15 is considered abnormal. The mean anterior head–neck offset ratio in our cohort (0.202) was similar to that described by Pollard *et al.*[15] in the general population as well to that reported by Eijer[12] and Clohisy[14] in their control groups. In our study, 10 out of 85 patients (11.76%) had an offset ratio of less than or equal to 0.15. This is similar to the estimated prevalence of 10–15% of FAI in the western population. In total, the mean values of alpha angle as well anterior head–neck offset of the Indian population were not different from those of the western population in contrast to our anticipation.

The small sample size is the primary limitation of the study and, in addition, the sample is probably not truly representative of the general population.

Our study shows that radiological features of abnormal head–neck offset are as prevalent in Indian hips as in western hips. The striking difference in the prevalence of primary osteoarthrosis of the hip between Indian and western populations, thus, cannot be attributed to morphological differences in the proximal femoral anatomy.

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