Original Communication

SEX DIFFERENCES IN THE ANTERIOR ACETABULAR RIDGE MORPHOLOGY

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ABSTRACT

Objectives: The anterior acetabular ridge morphology, an important consideration in the design of hip prosthesis, shows marked interethnic variability. There is however a paucity of local data highlighting the prevalence of the various anterior acetabular ridge shapes. Furthermore, sex-related differences have hardly been documented. Therefore, this study aimed to determine the shapes of the anterior acetabular ridge in a sample Kenyan population and the sex differences therein. Methods: Ninety-four paired hip bones (44 female, 50 male) from the osteology collection at the National Museums of Kenya were studied. The shape of the anterior acetabular ridge was determined and recorded. Results: The anterior acetabular ridge was curved in 34% of cases, straight in 24.5%, angular in 21.3% and in irregular 20.2% of the cases. The curved type was more frequent in females (50.0%) compared to males (20.0%). Conclusion: Sexual dimorphism influences anterior acetabular ridge morphology and which should be borne in mind during acetabular reconstructive procedures and design of acetabular prosthesis.

***Keywords**: sex differences; anterior acetabular ridge; curved*

RESUMEN

Objetivos: La morfología de la cresta acetabular anterior, una consideración importante en el diseño de prótesis de cadera, muestra una marcada variabilidad interétnica. Sin embargo, hay una escasez de datos locales que destacan la prevalencia de las diversas formas de la cresta acetabular anterior. Además, las diferencias relacionadas con el sexo apenas se han documentado. Por lo tanto, este estudio tuvo como objetivo determinar las formas de la cresta acetabular anterior en una muestra de población de Kenia y las diferencias de sexo en la misma. Métodos: se estudiaron noventa y cuatro huesos de cadera emparejados (44 mujeres, 50 hombres) de la colección de osteología de los Museos Nacionales de Kenia. Se determinó y registró la forma de la cresta acetabular anterior. Resultados: la cresta acetabular anterior fue curvada en el 34% de los casos, recta en el 24.5%, angular en el 21.3% e irregular el 20.2% de los casos. La curvada fue más frecuente en mujeres (50.0%) en comparación con los hombres (20.0%).Conclusión: el dimorfismo sexual influye en la morfología de la cresta acetabular anterior y debe tenerse en cuenta durante los procedimientos de reconstrucción acetabular y el diseño de prótesis acetabular.

***Palabras clave**: diferencias de sexo; cresta acetabular anterior; curva*

INTRODUCTION

The acetabulum is part of the post-cranial human skeleton and demonstrates considerable inter-population variation owing to demographic, ethnic and environmental influences (Imber, 2004). Morphologically, the anterior and posterior acetabular ridges are discernible. The posterior ridge is almost always semi-circular in shape with very little variations reported about it (Govsa, 2005). On the other hand, the anterior ridge shows considerable variation in shape with four distinct shapes documented: curved, angular, irregular and straight (Maruyama et al., 2001).

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The prevalence of the specific shapes however shows obvious ethnic differences (Aksu et al., 2006; Chauhan et al., 2002; Govsa et al., 2005; Maruyama et al., 2001; Ukoha et al., 2014). Furthermore, there is hardly any literature reporting on sex differences in the shape of the anterior acetabular ridge. This is despite acknowledgement that acetabular morphology is subject to sexual differences (Vandenbussche et al., 2007).

The morphology of the anterior acetabular ridge is an important guide to a variety of surgical procedures including prosthesis design during hip replacement (Govsa et al., 2005). In such cases, it has been reported that preference of reference morphologic and morphometric values from the native population has been useful (Murtha et al., 2008). Furthermore, links between morphology of the acetabulum and various hip pathology have been described(Msamati et al., 2003). This study therefore, aimed at describing the sex differences in the shape of the anterior acetabular ridge.

MATERIALS AND METHODS

A total of 94 dry hip bones (from 22 females and 25 males' skeleton) were obtained from the osteology collection of the National Museums of Kenya. Approval for use of specimens was obtained from the office of the Director of Repository and Research of the National Museums of Kenya. Only skeletally mature acetabula with closed triradiate cartilage that could be correctly identified for sex were used in the current study. Specimens with degenerated acetabula from osteoarthritis, deformities from fractures, evidence of bad preservation of coxal bones or skeletal disorders showing any obvious anomalies were excluded.

Each acetabulum was identified on the lateral aspect of the hip bone. The shape of the anterior acetabular ridge was classified by two observers and classified as angular, curved, irregular and straight [Figure 1 and 2] according to Maruyama et al. (2001).

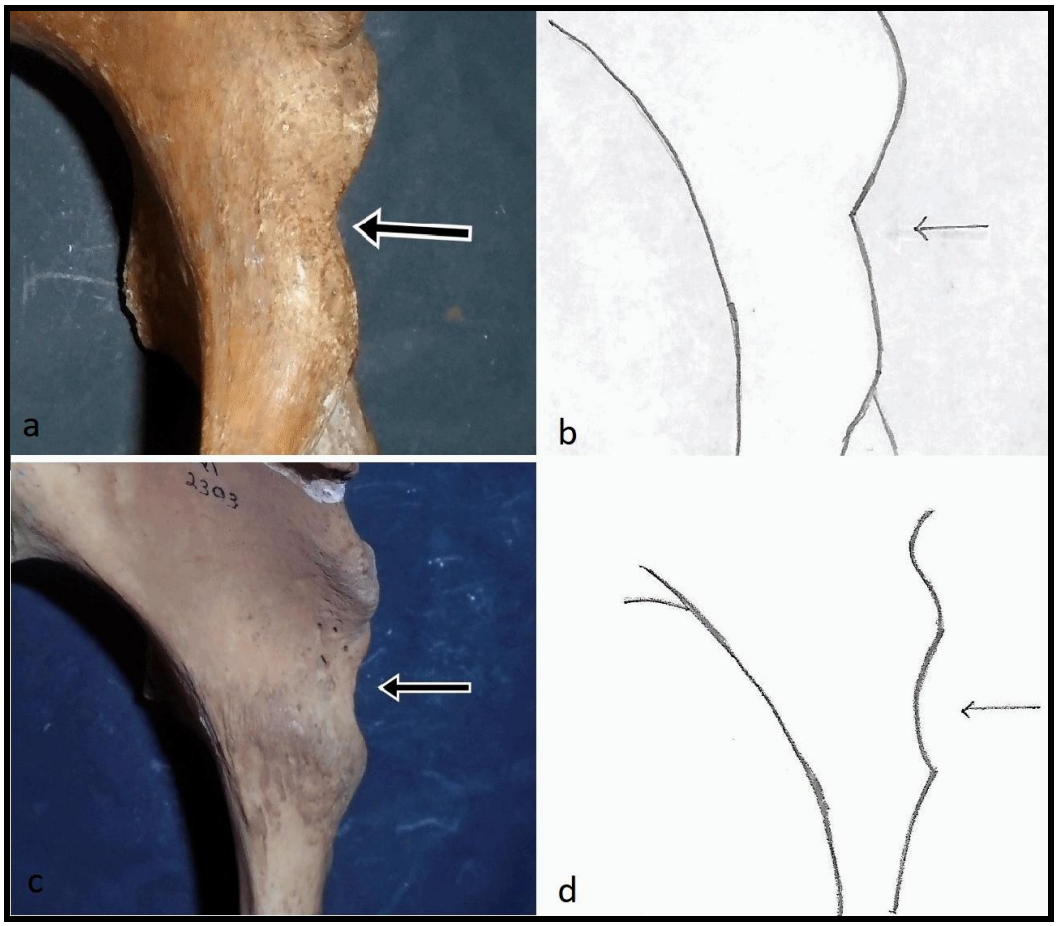


Figure 1- Image showing the angular and curved shapes of the anterior acetabular ridge (arrow). a - angular shape of anterior ridge of the acetabulum, b - Illustration. c- curved shape of anterior ridge of the acetabulum, d – Illustration

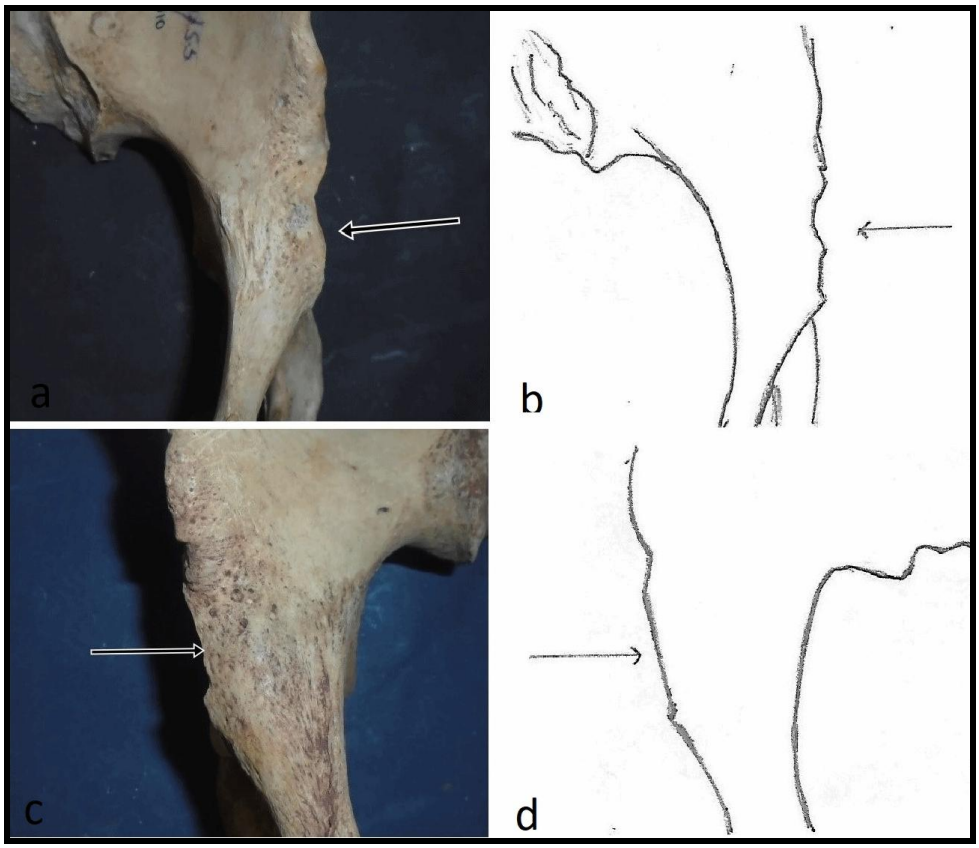
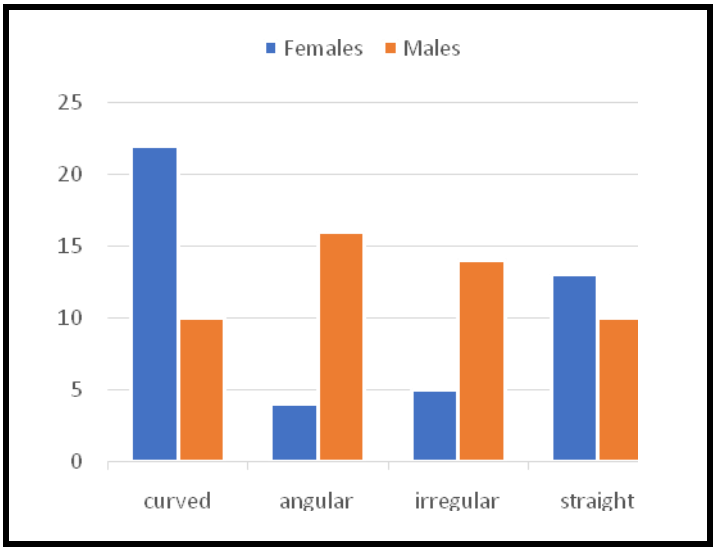


Figure 2- Image showing the irregular and straight shapes of the anterior acetabular ridge (arrow). a - irregular shape of anterior ridge of acetabulum, b – illustration. c - straight shape of anterior ridge of acetabulum, d – illustration



Graphic 1- Graph showing the distribution of the shapes of the anterior acetabular ridge in males and females

Data were recorded in the data collection sheet and analyzed using SPSS (Statistical Package for Social Sciences) version 21.0 Chicago, Illinois, USA and are summarized as percentages for tables and graphs. Sex and side distribution were further analyzed by Pearson's chi square statistic and a significance value set at $p \leq 0.05$.

RESULTS

Four distinct configurations of the anterior acetabular ridge were identified and noted as curved, straight, angular, or irregular (Graphic1 and Table 1). Most acetabula 32 (34.0%) had a curved configuration while an irregular type had the least distribution – 19 (20.2%). A curved anterior acetabula ridge was the most common type in females – 22 (50.0%) while an angular one was the least common – 4 (9.1%). In males, an angular acetabula ridgewas the most common – 16 (32%) while a curved one was the least common – 10 (20%). Sex differences in distribution of the identified morphological types was found to be highly statistically significant at a p value < 0.05 for curved and angular types but not for straight and irregular types. There were no significant side differences (Table 1).

DISCUSSION

The anterior acetabular ridge morphology is an important consideration in the design of hip joint prosthesis (Govsa et al., 2005; Zeng et al., 2012). It is also an established predictor of hip pathologies including developmental dysplasia of the hip (Delaunay et al., 1997; Msamati et al., 2003). The study of its variant anatomy is therefore of paramount significance.

The high prevalence of the curved configuration as reported in the current study is similar to findings from previous studies (Ukoha et al., 2014; Vyas et al., 2013). This could indicate, however, that race may not play a role in the morphology of the anterior acetabular ridge as it does with other morphometric variables of the acetabulum (Krebs et al., 2009). Race determines averages in stature and Body Mass Index (BMI) in a population, thus, racial difference is a major cause of population variation that influences population data (Hur et al., 2008). Besides this, the current study has determined that the curved type is significantly more frequent in females than males whereas other studies fail to indicate any relation to gender in their findings. Adult females outnumber males in a majority of the populations studied (Central Intelligence Agency, 2018). Agreater number of females in a sample could as well account for the higher frequency of the curved type in these previous studies, though not directly evidenced.

Shape of the anterior acetabular ridge	**Male n=50**			**Female n=44**			**Total No.(%) n=94**	**Chi square tests of independence**	
	Right	**Left**	**Total No. (%)**	**Right**	**Left**	**Total No. (%)**		**Sex vs shape**	**Side vs Shape**
Curved	6	4	10(20.0)	11	11	**22(50.0)**	**32(34.0)**	**χ^2 (1) =9.381 p=.002**	χ^2 (1) =.190 p>.05
Angular	9	7	**16(32.0)**	2	2	4(9.1)	20(21.3)	**χ^2 (1) = 7.333 p=.007**	χ^2 (1) = .254 p>.05
Irregular	6	8	14(28.0)	2	3	5(11.4)	19(20.2)	χ^2 (1) = 4.017 p=.045[a]	χ^2 (1) = .594 p>.05
Straight	4	6	10(20.0)	7	6	13(29.5)	23(24.5)	χ^2 (1) = 1.154 p>.05	χ^2 (1) = .058 p>.05

Table 1- Table showing the relationship of the morphological types of the anterior acetabular ridge to sex and side. χ2 = Pearson's Chi square statistic; a = not statistically significant following continuity correction

The sex related prevalence in the shape of the anterior ridge morphology as found in the current study could be alluded as a consequence of sex-linked variation in pelvic morphology (Jordaan, 1976). It is believed that the different anatomic morphologies of the pelvis in males and females are responsible for variation in the psoas valley and probably the anterior acetabular ridge (Kopydlowski et al., 2014). The psoas valley, a depression on the anterior acetabular rim, might also have an influence on the shape of the anterior acetabular ridge (Vandenbussche et al., 2008). This depression acts as a groove for the iliopsoas muscle as it tracts over the anterior of the acetabular rim. Differences in shape and size of the pelvis between the sexes additionally result in varied hip joint kinematics. Therefore, configurational differences in the anterior acetabular ridge are possibly evidenced by previous studies where sexual dimorphism in hip joint motion has been reported (Pollard et al., 2007; Wang et al., 2004) and as has been observed in the current study.

Furthermore, males have significantly heavier and thicker pelvic bones in response to their sturdier body size (Leong, 2006) as a response to more bone deposition than females and less bone loss with advancing age (Wolf et al., 2015). In addition to this, relative differences in muscle use and biomechanical loading on the hip joint affect hip joint motion. In this case, stronger muscle traction over the psoas valley in males would cause less bone loss at the acetabular rim contributing to an angular shape whereas a greater internal rotation in females could contribute to the curved configuration (Pollard et al., 2007). A study using the scaphoid bone in a Kenyan population similarly suggests this sexual dimorphism (Kigera et al., 2017).

Females in general have been reported to show more dysplastic features in the acetabulum (Atkinson et al., 2010). In sub-Saharan Africa, the prevalence of hip dysplasia is highest in females (Loder and Skopelja, 2011). Lavy et al. (2003) have associated this prevalence with morphological features of the acetabulum. More female than male pelvises expressed a curved type of anterior acetabular ridge. The curved type has been associated with a number of cases of developmental dysplasia of the hip (DDH)**.** The curved configuration is thought to be associated with a higher prevalence of DDH (Umer et al., 2006) as it offers deficient anterior cover for the femoral head (Zeng et al., 2012). This could provide anadditional link between acetabular morphology and the higher prevalence of DDH among females (Msamati et al., 2003). However, further epidemiological study on this relationship is recommended.

In conclusion, sexual dimorphism influences anterior acetabular ridge morphology and which should be borne in mind during acetabular reconstructive procedures and design of acetabular prosthesis.

Conflict of interest
There is no conflict of interest in this study

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Informed consent
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Ethical approval
Approval to conduct the study was given by the Director of Repository and Research of theNational Museums of Kenya.

Contributions
FG, JM, KO and KA conceived the idea and planned its execution. FG collected data. JM, KO and KA contributed to the analysis of the data collected. FG wrote the manuscript with the support of JM, KO and KA.All authors discussed the results and contributed to the final manuscript.

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