Evaluation of Greater Sciatic Notch Parameters in Sex Determination of Hip Bone by Three-Dimensional CT Images

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Evaluation of Greater Sciatic Notch Parameters in Sex Determination of Hip Bone by Three-Dimensional CT Images

SIAMAK SOLTANI1, MARYAM AMERI1, KAMRAN AGHAKHANI1, SOHEILA GHRBANI1

ABSTRACT
Introduction: Sex determination of an anonymous individual is one of the main objective when human skeletal remains are found, both in forensic investigation and archaeological studies.

Aim: To evaluate the role of Greater Sciatic Notch (GSN) parameters in sex determination in the Iranian population by means of Three-Dimensional (3D) images reconstructed by multi-slice Computed Tomography (CT).

Materials and Methods: In the present cross-sectional study, 237 cases (121 females and 116 males) who received Pelvic CT in radiology department of Rasoul-e-Akram Hospital were included. The GSN parameters including the width, depth and posterior segment were applied to measure the 3D-CT radiographs of participant’s hip bone using digital instruments with an accuracy of 0.01° and 0.01 mm. SPSS version 21 was used to analyse the data using the independent sample t-test, chi-square test, Pearson’s correlation test and Roc curve.

Results: Among the GSN parameters, depth had no difference among males and females, in both right and left sides (p=0.767 and p=0.561, respectively); thus, was not useful in sex determination. GSN parameters including Depth (p=0.008), Post segment (p=0.017), and Index 2 (p=0.015) were different in right and left sides and cannot be considered for sex determination without considering the sides. Moreover, Post angle (90.3%) and Post segment (89.5%) were found to have the most accuracy in sex determination.

Conclusion: Most of the parameters of GSN except for depth were useful for sex determination. Application of 3D-CT micrographs in the present study helped us to easily quantify sexual dimorphism in the GSN, suggesting 3D-CT can be considered as one of the valuable tools in practical forensic osteology investigation due to the great accuracy to measure the sex differences.

Keywords: Childbearing, Human skeletal remains, Pelvic bones

INTRODUCTION
Sex determination of an anonymous individual is one of the main step when human skeletal remains are found, both in forensic investigation and archaeological studies. Hence, evaluation of sexual dimorphism of bones in the human population is interesting for both forensic experts as well as anthropologists [1].

The hip bone is a perfect bone for sex determination; since, it reveals the dissimilarities between the two sexes and likewise displays a specific adaptation of women hip bone for childbearing [2]. It is believed that for the sex determination of human skeleton the hip bone shows the highest accuracy levels [3]. The sexual dimorphism in the shape and size of the pelvis is very great since women giving birth to infants [4]. The parts of the pelvis which are more resilient to damage can be used for sex determination, including the GSN and the auricular surface of the ilium [5]. In pelvis, the GSN has an advantage because it is recognisable early in fetal development. Studies have shown a statistically significant level of sexual dimorphism in GSN [6]. The form and size of the GSN are associated with the size of the pelvic inlet. Therefore, multiple studies have demonstrated that the GSN is highly accurate for estimating sex when used alone [7-9].

There are different methods for determination of sex in human skeletal remains including visual examination, bones anthropometric measurements, anthropometric measurements with use of statistics, X-ray examination, and Microscopic examination [10]. CT is a high speed method and can capture high level details of bones’ features and there is no need to remove soft tissue. Therefore, it is a perfect instrument to save time to protect remains from physical manipulation [11]. 3D-CT images of the pelvis reproduce complex curved features, and it stored data format facilitates computerised geometrical analysis which helps to archive the data and use them in the future [11,12]. There are many skeletal or collapse bodies in which determination of sex is the first step. No study has been performed previously in Iran, using GSN 3D-CT scan for sex determination.

The present study was done to evaluate the role of GSN parameters in sex determination in the Iranian population by means of 3D images, reconstructed by multi-slice CT.

MATERIALS AND METHODS
Study Design and Participants
In the present cross-sectional study, 237 cases (121 females and 116 males) who had undergone pelvic CT for various reasons, in Rasoul-e-Akram Hospital between September 2016 and February 2017 were included in the study. All the patients who met the inclusion criteria were enrolled in this six month study. Sample size was calculated using \( \alpha = 0.05, \beta = 0.2, \mu_1 = 27.06, \mu_2 = 25.41, SD_1 = 3.53, SD_2 = 3.37 \) (20) and was estimated to be minimum sample of 140 cases.

Inclusion and Exclusion Criteria
Patients who underwent pelvic CT according to their physician’s advise were included in the study. Individuals who had severe pelvic injuries due to a fall or accident, those who had deformed or malformed bones and also with congenital abnormalities as well as non-Iranians, were excluded from the study.

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Keywords: Childbearing, Human skeletal remains, Pelvic bones
**Ethical Considerations**

The study was performed according to the Ethical principles of declarations of Helsinki. The study is approved by Ethical Committee of Iran University of Medical Sciences. (Ethical code: IR.IUMS.FMD.REC.1396.9411223010) All patients were aware of the study and a written informed consent was obtained from each participant.

**Data Collection**

The GSN parameters including the width, depth and posterior segment were applied to measure the 3D-CT radiographs of participants’ hip bone using digital instruments with an accuracy of 0.01º and 0.01 mm [Table/Fig-1]. The measured data with sex information were then recorded in a checklist. At first, the GSN landmarks (Pyriformis tubercle, Ischial Spine and the deepest point of the GSN) were determined by Ruler Syngo software in the division then the following parameters were measured.

- Maximum width (AB): Measured as the distance between the pyriformis tubercle (B) and the point of the ischial spine (A).
- Mid width (EF): GSN width at midpoint of OC line.
- Maximum depth (OC): Considered as the perpendicular distance between the deepest points of the GSN (C) to the maximum width.
- Posterior segment (OB): Measured as the distance between pyriformis tubercle (B) and the point of O (Vertical cross-sectional width and the maximum depth of GSN).
- Index I= Depth OC/Width AB×100
- Index II=Posterior segment OB/Width AB×100
- Index III (EF/AB)
- Index IV (EF/CO)
- Total angle=ACB: Measured as an angular distance between the point of pyriformis tubercle (B), the deepest point of the GSN (C) and the point of Ischial spine (A).
- Posterior angle=BCO: was determined as an angular distance between the point of pyriformis tubercle (B), deepest point of the GSN (C) and the point of O.

**RESULTS**

A total of 237 cases (121 females and 116 males) with the mean age of 50.53 years (20-89 years) participated in this study. Equality of means was evaluated by the independent Student’s t-test and p-values were calculated. Statistically significant differences between means related to sex were found for parameters including Max width (p<0.001), mid-width (0.001), Total angle (<0.001), Post angle (<0.001), Post Segment (<0.001), index 1,2,3 and 4 (<0.001). While there was no difference between Max depth and means related to sex in right (p=0.767) and left side (p=0.561) [Table/Fig-2].

The parameters Depth (0.008), Post segment (0.017), and Index 2 (0.015) showed statistically significant differences in two sides of the body; however, the other parameters showed no differences in right and left sides and can be used for sex determination [Table/Fig-3]. Correlations between all parameters and age were analysed using Pearson's correlation coefficient test. There was no statistical difference between age and most variables of the GSN in men (p>0.05). All of the parameters except right AB (r=-0.195, p=0.036), mid-width right (r=-0.328, p<0.001) and left (r=-0.352, p<0.001), index 3 right (r=-0.201, p=0.031) and left (r=-0.246, p=0.008) and index 4 right (r=-0.196, p=0.035) had no correlation with age.

In comparison with men, significant correlation was found between age and right mid-width (r=-0.268, p=0.003), left mid-width (r=-0.290, p<0.001), left OB (r=0.198, p=0.029), left index 2 (r=0.221, p=0.015), index 3 right (r=-0.381, p<0.001) and left (r=-0.483, p<0.001) and 4 right (r=-0.320, p<0.001) and left (r=-0.285, p=0.002) (p<0.001) in women [Table/Fig-4].

Roc curve was used to determine the sensitivity and specificity of the parameters. The most accuracy in sex determination was seen in post angle and post segment 90.3% and 89.5% respectively. The most sensitivity belongs to Total angle. Post angle and post segment have the most specificity (91.1%) [Table/Fig-5,6].

**DISCUSSION**

The hip bone is usually considered as an important sexually dimorphic region of the human skeleton and the GSN is one of the main features that is normally used as a reliable source for sex determination [8]. Given the sexual dimorphism in different patterns and levels, the standards of specific populations and species cannot be applicable for all human beings. By measuring several variables simultaneously through the digital tools and electronic software, it is possible to increase accuracy and reduce error in sex determination analyses. Among different tools, the GSN parameters are a reliable indicator of sex determination. The present study compared different patterns of GSN parameters involved in sex determination of Iranian population using CT micrographs.

In the present study, the GSN was wider in female than male (respectively p<0.001). The result of the study is consistent with
Comparison of different GSN parameters in left and right sides with regard to sex.

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[Table/Fig-2]: Comparison of different GSN parameters in left and right sides with regard to sex.

[Table/Fig-3]: Comparison of different GSN parameters in right and left sides.

other previous studies. In studies of Dryaness S et al., (p<0.05), Kalsey G et al., (p=0.02) and Devadas P et al., (p<0.0003), the width is greater in female than in male [10,13,14]. The width is significantly different in female (p<0.001) and male (p<0.001) in both sides. Jain SK and Choudhary AK, showed that the width is larger in left side in male (p<0.05) and larger in right side in female (p<0.05) [15]. In another study by Kalsey G et al., the width was larger on the left side for female and on the right side for male although the difference was not significant (respectively p=0.533 and p=0.551) [13]. This difference in results can be due to racial differences. In addition, the Midwidth is greater in female than male in the present study (p<0.001). This parameter is slightly larger in left side (p=0.159) both in male and female. The Midwidth is significantly different in female (p<0.001) and male (p<0.001) in both sides. In previous studies this parameter of GSN was not evaluated.

The results of the current study revealed that the depth parameter was not significantly different in male and female on right (p=0.767) and left sides (p=0.561). This means that the depth parameter cannot be used for sex determination. The result of the present study is consistent with the studies of Dryaness S et al., right (p<0.05) and left sides (p=0.212) that showed that the depth is not significantly different between male and female [10]. In the study by Kalsey G et al., the result was the same and there was no significant
difference in depth in two sexes (p=0.06) [13]. However, in the Raut R et al., and Naqsh BF et al., study the maximum depth showed a significant different between the two sexes (respectively p<0.05 and p=0.006) [16,17].

Total angle is significantly different in male and female in both right and left sides (p<0.01). Moreover, total angle is not significantly different in two sides (p=0.624). These findings are similar to Dnyanesh S et al., Kalsey G et al., Raut R et al., study. They showed that the total angle is significantly different in both right and left sides and it is greater in male (p<0.001). In addition, there is no difference in Index 1 in two sides (p=0.540). The female had larger width they had smaller Index 1. The result are consistent with the results of Shah S et al., Dnyanesh S et al., and Kalsey G et al., studies [2,10,13].

Index 2 showed a significant different between male and female in both sides (p<0.001). Index 2 was significantly different in right and left sides (p=0.015). Index 2 is calculated by dividing OB/AB and since the post segment is meaningfully higher in female, the index 2 parameter is higher in female. Hence, it cannot be used for sex determination without considering the side. The result are consistent with the results of Shah S et al., Dnyanesh S et al., and Kalsey G et al., studies [2,10,13].

In the present study, the most accurate parameters for sex determination were posterior angle and posterior segment width (90.3% and 89.5% respectively). In a study by Takahashi H et al., it was shown that the most accuracy rate was related to Post Angle with accuracy of 91% which is similar to the result of present study [21].

LIMITATION

Since, the parameters were measured manually, there was a possibility of mistake in measurement.

CONCLUSION

Except for depth, the other GSN parameters are different between male and female can be used for sex determination. Except for Depth, post segment and Index 2, most of the parameters are not statistically different between right and left sides, so they can be used for sex determination irrespective of their sides. Moreover, post angle and post segment have the most accuracy in sex determination. Application of 3D-CT micrographs in present study helped us to easily quantify sexual dimorphism in the GSN, suggesting 3D-CT can be considered as one of the valuable tools in practical forensic Osteology investigation due to the great accuracy to measure the sex differences.

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PARTICULARS OF CONTRIBUTORS:
1. Assistant Professor, Department of Forensic Medicine, Iran University of Medical Sciences, Tehran, Iran.
2. Assistant Professor, Department of Forensic Medicine, Iran University of Medical Sciences, Tehran, Iran.
3. Professor, Department of Forensic Medicine, Iran University of Medical Sciences, Tehran, Iran.
4. Assistant Professor, Department of Forensic Medicine, Iran University of Medical Sciences, Tehran, Iran.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Soheila Ghorbani,
Assistant Professor, Department of Forensic Medicine, Iran University of Medical Sciences, Tehran, Iran.
Email: sghorbani2005@yahoo.com

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