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Sexual Dimorphism in Human Sacrum in Western (UP) Population using MDCT

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Abstract:-

- ***Objective:***

The objective of this study was to evaluate the role of 3D CT in Forensic Radiology for gender estimation and toestimate the difference in curvature between male and female sacrum using volume rendering.

- ***Methods:***

A total of 30 patients from known age (20-60) which include 17 males and 13 females these patients were taken from teerthanker mahaveer hospital and research center, all the patients reffered for CT L-S spine. All the patients fulfilling inclusion criteria for scan to be done 2D images were then converted in 3D data by using IRS technique, various measurements were done from MPR and 3D image.

- ***Results:***

From all the studied measurements, were as L-S Angle , Anterior sacral Angle, Sacral Base Angle, height, width and curvature of the sacrum. In this study LSA and SBA was found higher in females than males, also it was found that curvature and width of sacrum was higher in females, ASA and height of sacrum found higher in males as compered to females.

- ***Conclusion:***

After completion of study it was concluded that the prevalence of male case was higher than that of female cases according to the present study. In the persent study the various parameters of the sacral index were found to be significant assocated with respect to the gender.

Keywords:- *Lumbosacral Spine, Multiplanar Reconstruction, Multi detector Computed Tomograpy, Image Reconstruction system, Three dimensional, Sacral Base Angle, Anterior Sacral Angle, L-S Angle.*

I. INTRODUCTION

CT (computed tomography) is anticipated on the basic rule that the thickness of the tissue passed by the x- ray shaft is regularly estimated from the computation of the attenuation coefficient.

A. Principle of Computed Tomography

The fundamental standard behind CT is that the inward structure of an article can be remade from various projections of the object.

3D volume rendering, is the post processing technique and produce 3D images that have a better image quality.

Multiplanar reformation, is the process of using data from axial CT image to create non axial two dimensional.[1]

B. Multi-Slice Computed Tomography

The Multi-Slice CT (MSCT) is a CT framework furnished with various lines of CT finders to make pictures of numerous segments. This CT framework has various attributes from customary CT frameworks, which have only one line of CT finders. The presentation of this propelled identifier framework and its blend with helical filtering has notably improved the exhibition of CT as far as imaging range, time for assessment, and picture resolution.

C. Image Reconstruction Technique

Picture reproduction in CT might be a numerical activity that produces tomographic pictures from X-beam projection information obtained at different edges round the patient. Picture remaking impactsly affects picture quality and in this way on radiation dose.An calculation is a numerical strategy for comprehending a problem.the following three scientific techniques for picture recreation will be depicted:

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➢ *Back Projection*

Back projection sometimes called 'summation method' is the oldest means of image reconstruction .None of the commercial CT scanners uses simple back projection ,but it is the easiest method to describe so we will use it as prototype.

➢ *Iterative Methods*

An iterative remaking begins with a presumption (for instance, that all focuses in the network have and contrasts this suspicion and estimated values makes amendments to bring the two into understanding and afterward rehashes the procedure again and again until the expected and estimated values are the equivalent or inside satisfactory limits.There are three varieties of iterative reproductions, contingent upon whether the remedy grouping includes the whole lattice, one beam, or one point.

➢ *Simultaneous Reconstruction*

All projections for the whole grid are determined toward the start of the cycle, and all redresses are made at the same time for emphasis.

➢ *Ray- by-Ray Correction*

One beam entirety is determined and revised and these amendments are consolidated into future beam wholes with the technique being rehashed for every single beam in every cycle.

➢ *Point-by Point Correction*

The computations and remedies are made for all beams going through one point and these rectifications are utilized in resulting counts again with the procedure being rehashed for each point.

➢ *Analytic Methods*

Explanatory strategies diagnostic techniques are utilized in practically all X- raybeam CT today. These calculations vary from iterative strategies in that careful equations are used for the explanatory reproductions. These equations are alarmingly unpredictable to most radiologists despite the fact that mathematicians state they are actually very basic. We will just endeavor a pictorial clarification of the two mainstream scientific techniques two-dimensional Fourier investigation and separated back projection. .

➢ *Two-Dimensional Fourier Analysis*

The premise of Fourier investigation is that any capacity of time or space can be spoken to by the entirety of different frequencies and amplitudes of sine and cosine waves.

➢ *Filtered Back-Projection*

Sifted back projection is like back-projection aside from that the picture is separated or adjusted,to precisely offset the impact of abrupt thickness changes which causes obscuring in basic back projection.[2]

D. Sacrum Anatomy

The name sacrum is gotten from the Latin and Greek underlying foundations of os sacrum which means hallowed bone.

The human sacrum is a huge triangular combined bone of five separate vertebras that wires alongside the mediating intervertebral plates, shapes the postero-superior mass of pelvic hole, Wedged between the two innominate bones. The sacrum offers backing to the erect prostrate and assists with giving security and solidarity to the pelvis during the transmission of burdens from the hub spine to the pelvic girdle.The sacrum verbalizes with four bones; the upper piece of the sacrum is associated with the last lumbar vertebra above by means of a circle space and feature joint complex, as a rule it starts when the five unfused vertebra begin melding at the age of 16-18 years and finishes its combination arranges a solitary bone at 34 years old years. The three distinct surfaces of sacrum which are formed to oblige different structures.the state of the sacrum bone is raised looking ahead and it is curevd upon itself set sideways .in chilhood individual sacral vertebrae are associated via ligament and detachable by maceration. The grown-up bone holds numerous vertebral highlights. It comprises of base, pelvic dorsal and horizontal surfaces, sacral zenith and sacral cannal.

➢ *Base of Sacrum(Fig.1)*

It is shaped by the upper surface of S1.the body is enormous and more extensive transversely, its front projection edge the sacral projection. The vertebral foramen is triangular, its pedicle being short and dissimilar posterolaterally. The laminae are slanted, coordinated posteromedially to meet at spinous tubercle. Better articular procedures coordinated posteromedially than articulate with sub-par articular procedure of L5. Transverse procedure is abroad slanting mass tasks along the side from the body, pedicle and unrivaled articular procedure are interesting highlights of sacrum. The transverse procedure and costal components are combined togetherto the remainder of the vertebrae shaping the predominant piece of the sacral horizontal mass or ala.

➢ *Sacrum pelvic surface(Fig.2)*

Faces antero-inferiorly, It is vertical and transversely inward. Be that as it may , S2 may create a convexity. Four sets of pelvic sacral foramina with the sacrum cannal, transmitting ventral rami of upper 4 sacral spine nerves. The enormous region among right and left foramina, framed by level pelvic parts of the sacrum bodies shows their combination by 4 transverse edges. The bars between foramina are the costal components,combined to the vertebrae. The parallel piece of the sacrum is armed by the combination of costal components with transverse procedures.

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➢ *Sacrum Dorsal Surface (Fig.3)*

Sacrum dorsum surface is raised and pretender prevalent. It has a rised intruded on, middle sacral peak with 4 spinous tubercules speaking to intertwined sacral spines. Beneath the fourth or third a curved sacral rest is available in the back mass of the sacral channel which is because of disappointment of the fifth pair of laminae to meet, in the inside uncovering the dorsal surface of fifth sacral body. Horizontal to the middle peak are the 4 sets of dorsal foramina which lead into the sacral cannal through intrervertebral foramina, each transmitting the dorsal ramus of a sacral spinal nerve. Average to the foramina, vertically underneath each articular procedure lays 4 msall tubercles all things considered called the moderate sacal peak.

The fifth mediocre aticular process extends caudally and flanks the sacral break as sacral cornua. Sidelong to the dorsal sacral foramina is a horizontal sacral peak, framed by the intertwined transverse procedures, whose apices show up asa line of transverse tubercles.

➢ *Sacrum Lateral Surfaces (Fig.4)*

This is the combination of transverse procedures and costal components which are wide above and tight beneath. The wide upper part bears an auricular surface for explanation with ilum which resembles a reversed last 'L' . The shorter cranial appendage is confined to the S1 and caudal appendage slipping upto the center of S3. Past this the sidelong surface is non – articular and decreased in expansiveness. Caudally it bends medially to the collection of S5 at the second rate parallel edge. Past which the surface becoms a slender parallel outskirt. The auricular surface shows cranial and caudal rise a halfway melancholy.

➢ *Sacral Apex*

The inferior aspect of body of S5which bears an ovel facet for the articulation with coccyx.

➢ *Sacral Canal*

framed by the sacral vertebral foramina, it is triangular in segment. Basal opening is diagonal because of sacral tendency, is derected cranially in the standing position. Every horizontal divider presents 4 intervertebral formaina, through which they are continous with pelvic and dorsal sacral foramina. Its caudal opening is the sacral rest.[3]

II. METHODS

The study was conducted at Department of Radiology, Moradabad.

A. Type of the Study:

Retrospective study.

B. Setting:

It is a retrospective study that was conducted over 1 year at the Radiology department of Teerthanker Mahaveer hospital Moradabad U.P. This study carried out on PHILIPS INGENUITY CORE 128 slice CT Machine.

C. Inclusion Criteria:

- Patients of western (UP) population of age group 20-60years
- Patient referred for CT L-S Spine and Pelvic CT
- Both male and female patients
- Female patients need to fulfill 10 day rule
- Previous normal data can be retrieved from the system

D. Exclusion Criteria:

- Trauma cases are excluded
- Patient with pot's, metastasis are not included

E. Sample Size:

We used appropriated routinely protocol for CT L-S spine. A total of 30 patients (Age 20-60) are included in this study to differenciate in curvature between male and female. sample who visited in Teerthanker Mahaveer hospital for their diagnosis in CT modality.

F. Technique of Examination:

All patients are screened before entry into the CT scanner room for metallic objects of the interest of part. Patients were examined in the supine position on the patient table with proper positioning .The L-S spine protocol [4] initial topogram of the L-S spine has obtained. CT L-S spine protocol (Tabl 1) at 128 slice includes the spine , set the protocol (KVp, mA, slice thickness, Interslice gap etc.), protocol also include axial plain with 3 mm slice thickness, there by reconstruction, post processing and reformatting images into multiple planes.

- To find the accuracy of gender estimation by taking various measurements of the following parameters
- It would be helpful in forensic department to identify the damaged \degraded body with their sacrum

✓ L-S Angle
✓ Sacral base angle
✓ Anterior sacral angle

- Diameter

✓ Max. height
✓ Max width

- Curvature

✓ Anterior

All the patients fulfilling inclusion criteria will be informed and instructed for the scan to be done. 2D images then will be converted to 3D data by using Image reconstruction technique. Various sacrum parameter measurements (Table 2) will be taken from MPR and 3D image.All the collected data will further be send for statistical analysis.

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G. Data Management Statistical Analysis:

The data was collected and entered in MS excel 2013. Different Diverse measurable examination was performed utilizing SPSS programming rendition 22. The one sample Kolomogorov - Smirnov Test will be employed to determine whether the data sets different from a normal distribution or not .Descriptive statistics will be calculated for quantitative variables.

Wilcoxon test for significant risk factors were done by logistic regression method.

In result, If $p<0.05$ then hypothesis is said to be statistically significant and if $p>0.05$, then hypothesis is said to be statistically insignificant.

III. RESULT

After CT L-S Spine procedure out the inclusion criteria, a total 30 patients of both gender and different age group were included in the present retrospective study. An informed consent was obtained from all the patients before they were subjected for evaluation. Out of 30 patients are included in this study, 13/30 (44%) patients females and 17/30 (56%) patients males. Maximum number of MDCT patients was in the age group of 20-60 Years .Table 3 & Graph 1 show the gender-wise distribution of the study subjects illustrating the frequencies . The prevalence of male cases (56.7%) was higher than female cases (43.3%).

The present study was an attempt to estimate the difference in curvature between male and female sacrum using volume rendering and to evaluate the role of 3D CT in forensic radiology for gender estimation according to the available data of thirty cases with relation to the various parmeters. The various parameters were selected on the basis of various reviews of literatures. In the present retrospective study, which was conducted at TeerthankerMahaveer Hospital & Research Centre, recruited a total of thirty cases consisting of 17 male cases followed by 13 female cases.

For all the parameters taken under consideration, the mean, standard deviation and interquartile range were depicted. As per the overall variability of the study subjects, the mean age and the standard deviation was found to be 30.09 and 8.298 (with the interquartile range = 11). The mean of Lumbo sacral angle was found to be 52.74 with the standard deviation of 5.21 whereas the mean Anterior Sacral angle was found to be 57.68 with the standard deviation of 3.208 (Interquartile range=2.92). Moreover, the mean Sacral Base angle was 37.18 with the standard deviation of 5.960 (Interquartile range=5.960) (Table 4)

According to the gender-wise comparison of the study population, in case of female patients the mean ± Std. Deviation of LSA was found to be 55.346±3.68, the mean ± Std. Deviation of ASA was 56.215±1.937, the mean ± Std. Deviation of SBA was 39.315±5.841 whereas in male cases the mean ± Std. Deviation of LSA was found to be 50.759±5.4217, the mean ± Std. Deviation of ASA was 58.811±3.569, the mean ± Std. Deviation of SBA was 35.552±5.682. Therefore, a significant association was observed between the parameters like LSA, SBA and ASA with p-value <0.05 (CI -95%). The mean ± Std. Deviation of other parameters like Height, width and curvature in female cases were found to be 8.953±0.602, 11.5323±0.600 and 129.4±5.7373 respectively whereas in male cases the mean ± Std. Deviation of parameters like Height, width and curvature was found to be 10.117±1.091, 10.754±0.480 and 123.441±7.907 respectively(Table 5 and Graph 2)A significant association was observed between these parameters and the gender (p-value <0.05).

IV. DISCUSSION

In the present study, as per the several sacral parameters amongst different population groups, it was observed that the mean of LSA, SBA and ASA was higher in female cases as compared to that of male cases. Similar to our study, the results revealed by the study conducted by Davivongs et al.[5] has shown that the sacral index was more in females than that of males. Another study conducted by Kumar A et al.[6] also showed that the mean sacral index was higher in females. Hence it can be summarised from the present study that the most of the values for the parameters like LSA, SBA, ASA, the width as well as the anterior and posterior curavature were higher in females whereas the other parameters like the height was higher in male cases. However, according to a study conducted by Frazer et al.[7], it is revealed that as compared to the male cases, the bone of females is broader, showing a different curve anteriorly. In males the bend is less or progressively uniform from above downwards though if there should arise an occurrence of females it is stamped pointedly at the lower part. As shown in our present study the value of the curvature was found to be higher in females. Similar findings were seen in the sacrum studied by Kanika et al.[8] ,Mishra et al.[9],Sachdeva et al.[10] Steyn et al.[11]Abhimanyu et al.[12] , Sibani Mazumdar et al.[13] , Renuka et al.[14] Raju et al.[15].The sacrum is more curved in men than in women.

V. CONCLUSION

The present study aimed at estimating the difference in curvature between male and female sacrum using volume rendering and in evaluating the role of 3D CT in forensic radiology for gender estimation. The prevalence of male cases was higher according to the present study.

In the human skeletal framework, the distinguishing proof of gender turns out to be progressively significant as sacrum is a segment of pelvic support with utilitarian contrasts between the two gender. In the present study the various parameters of sacral index like LSA, SBA, ASA, height width and the anterior curvature were found to be significantly associated with respect to the gender.

Amongst all the indices, the height was found to be the most significant factor associated with both gender. The anterior curavatures were broader in females as compared to male cases which were preferably similar to the investigations done by several investigators.

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Hence, the present study suggests that during the surgical procedures, these parameters must be taken foremost under consideration. Moreover, the analysis of human sacrum can be used as a supportive finding in the estimation of the differences in the curvature. Furthermore, more studies can be done using a large sample sizes for the efficient observations.

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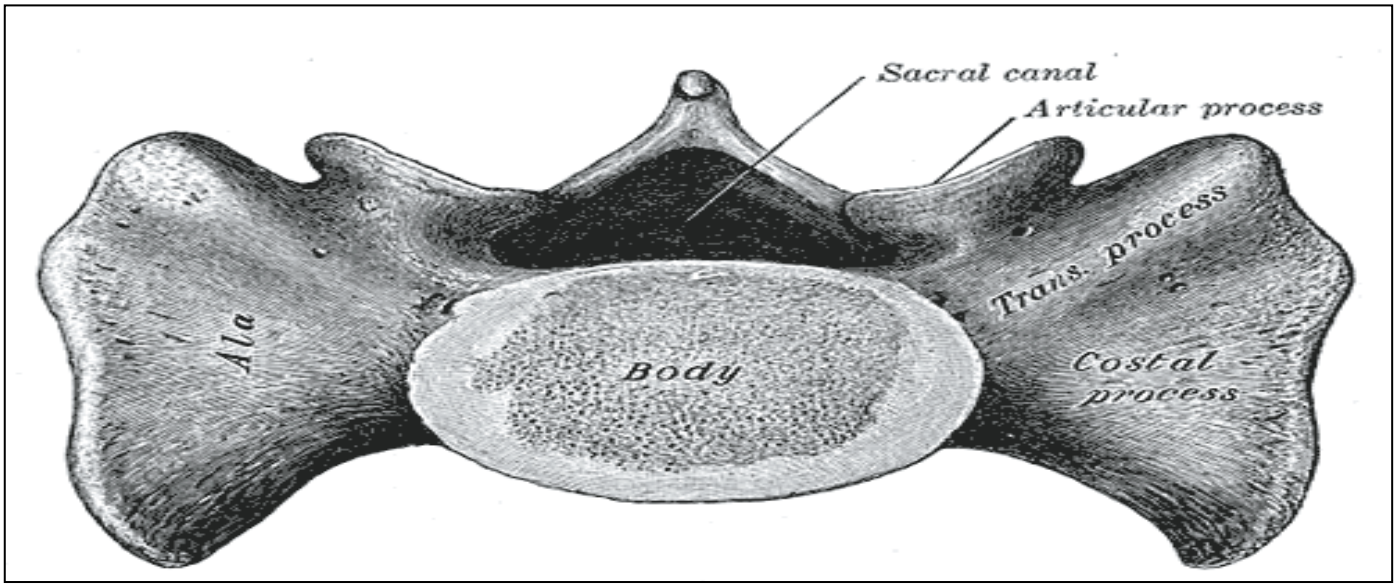

Fig 1: Base of Sacrum

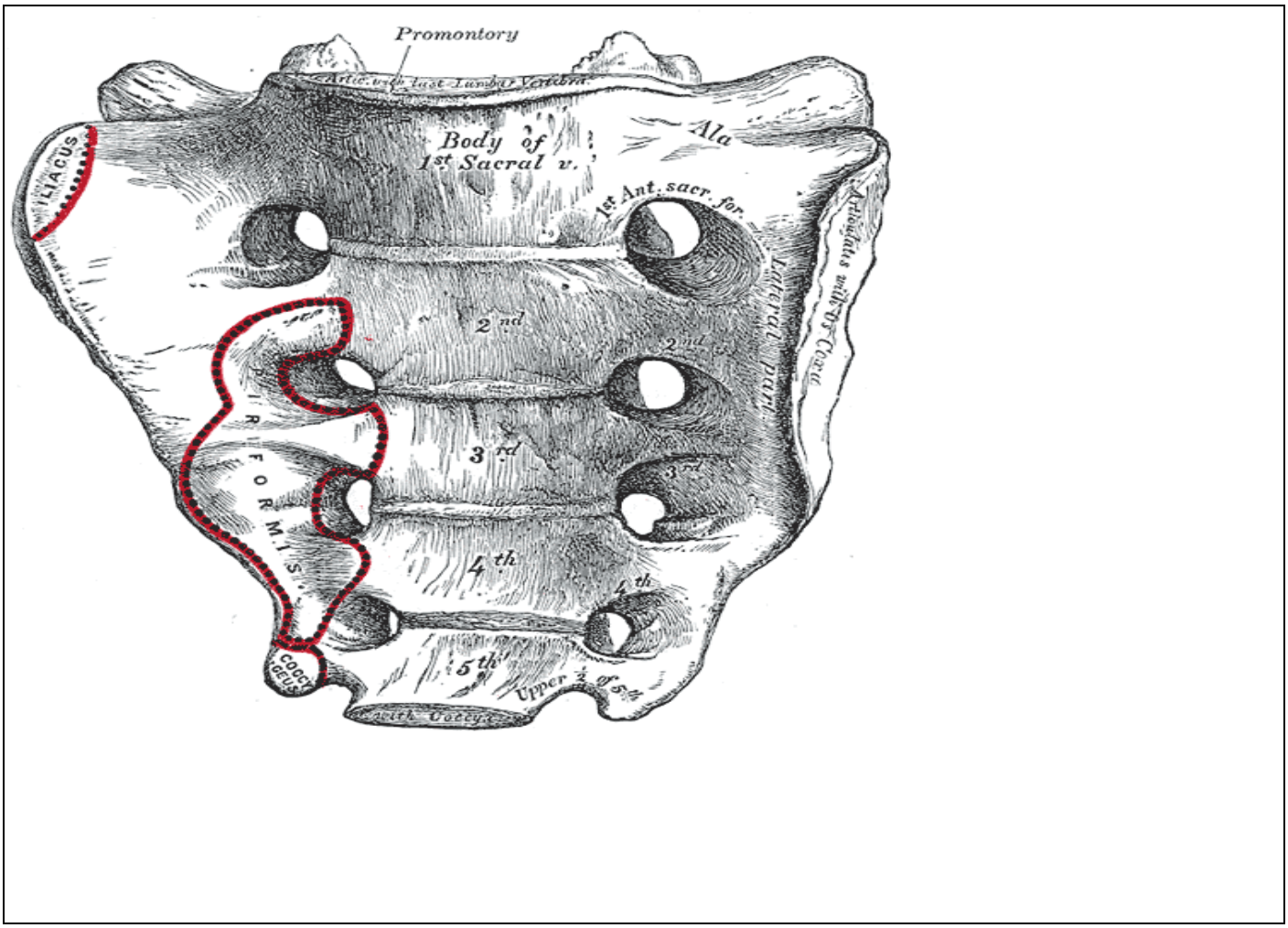

Fig 2: Sacrum Pelvic Surface

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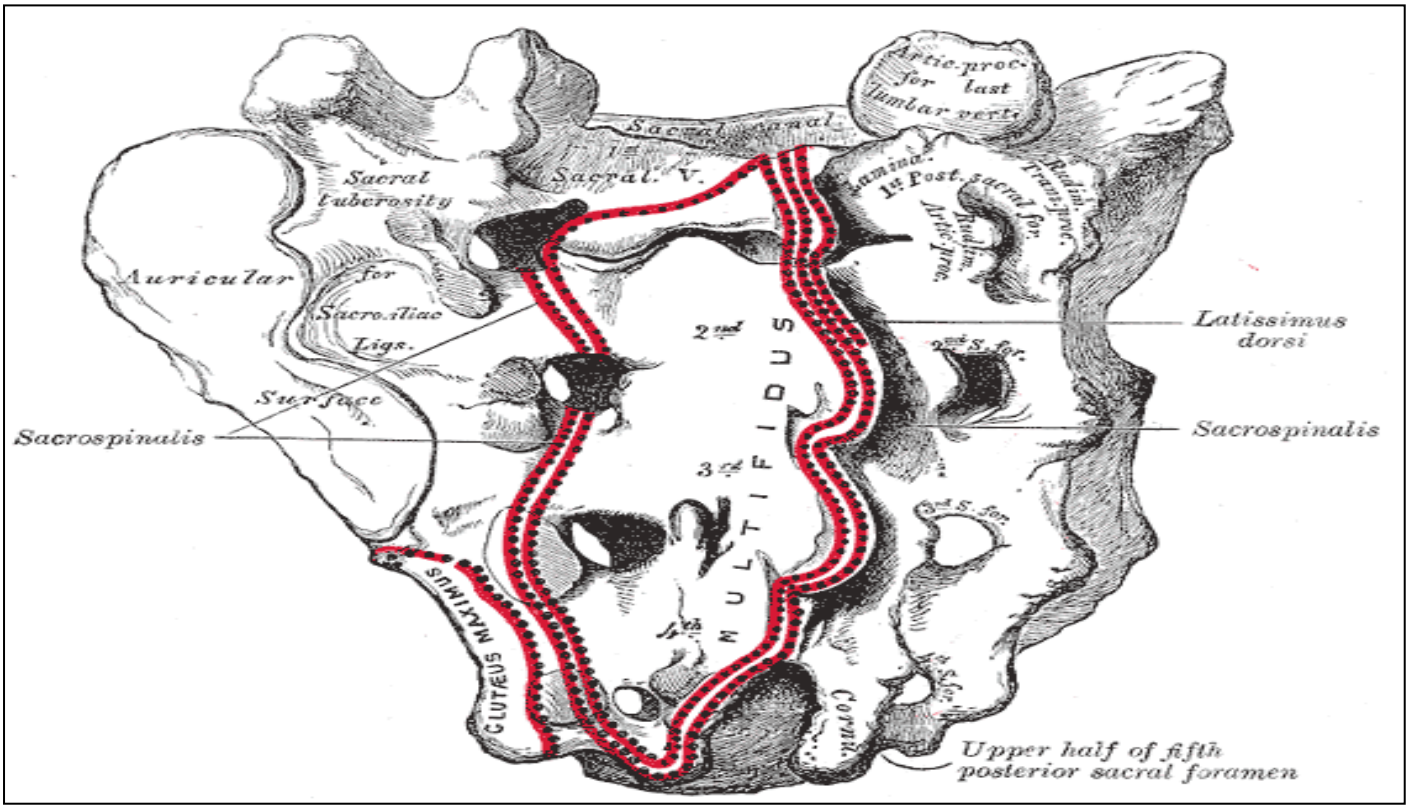

Fig 3: Sacrum, Dorsal Surface

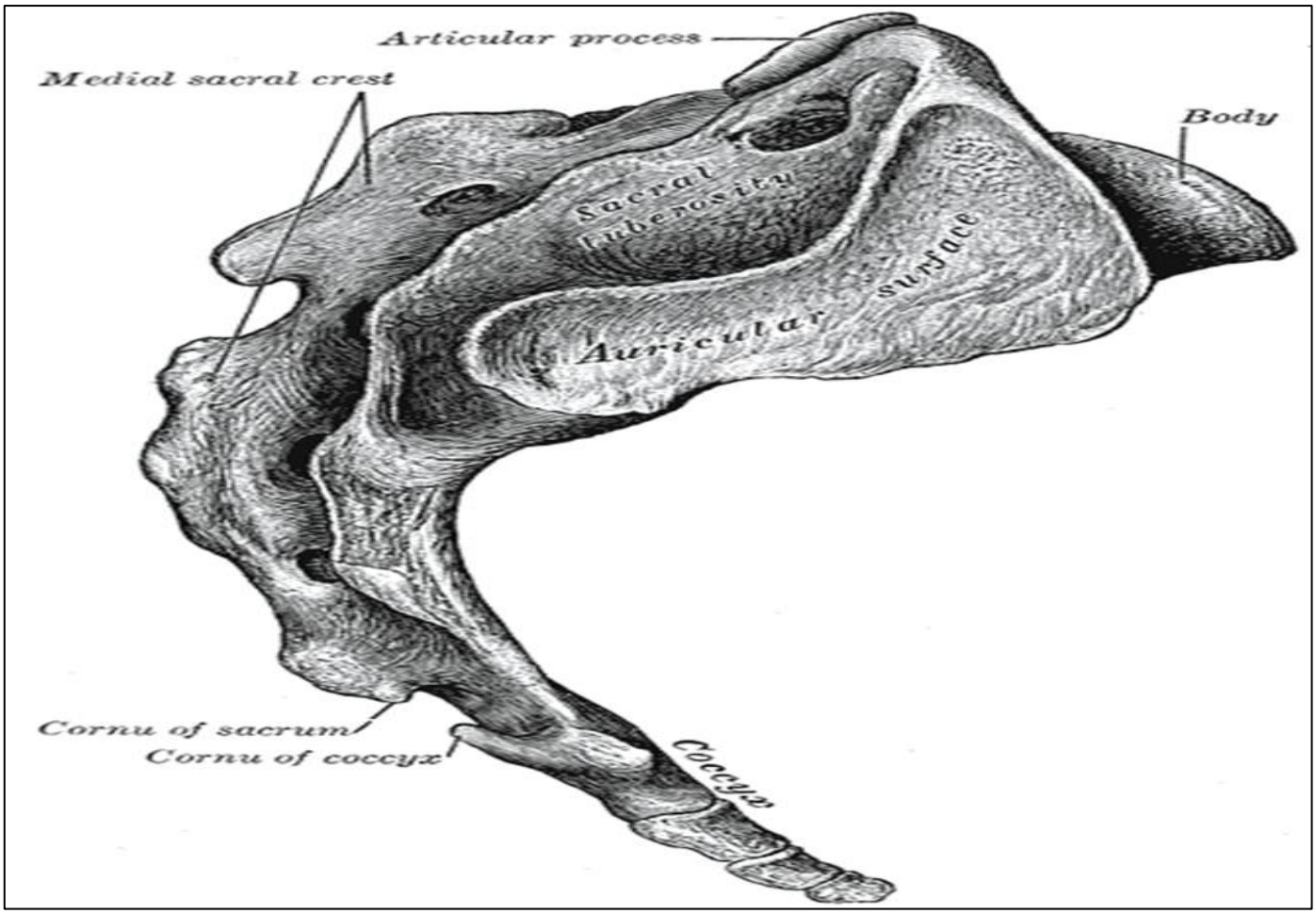

Fig 4: Lateral Surfaces of Sacrum

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TABLES

Table 1: CT Protocol for L-S Spine

L-S SPINE	
Protocol	*Spine helical*
Patient position	*Spine feet first*
Scano	*180^0 DUAL Scout*
Area coverage	*Spine*
Scan direction	*Crania caudal*
Routine plain	
Collimation	*64X 0.625*
Slice thickness	*3mm*
Increment	*3mm*
Kv,mAs/slice	*140,250*
Resolution	*Standard, Filter, sharp,*

Table 2: Parameters of Sacrum Measurements

Parameters	**Measurements**
Lumbo sacral angle (LSA)	The edge between the foremost fringe of s1 vertebral body and that of the fifth lumbar vertebral
Sacral base angle (SBA)	The edge between the unrivaled fringe of s1 vertebral body and the even line
Anterior sacral angle (ASA)	The edge between the unrivaled and foremost fringes of s1 vertebral body
Maximum height	The hight was estimated along the center of anterio better edge of promontary than center of antero sub-par edge of last sacral vertebra
Maximum width	The width was estimated from the sidelong most piece of alae of sacrum at the upper piece of auricular surface and the separation was estimated along foremost part of sacrum at the degree of Ist sacral vertebra
Anterior curvature	it was measured by taking maximum height of sacrum /curvature length of sacrum ×100

Table 3: Gender-Wise Distribution of the Study Subjects (N=30)

Gender	**Frequency (f)**	**Percent (%)**
Female	13	43.3
Male	17	56.7

Table 4: Representation of Mean with Variability and Interquartile Range in the Sample Characteristics

Variables	**Mean ± Std. Deviation**	**Interquartile Range**
Age	**30.9±8.298**	**11**
LSA (degree)	52.74667±5.212	7.1
ASA (degree)	57.68667±3.208	2.92
BSA (degree)	37.18333±5.960	7.85
Max Height (cm)	9.613333±1.07	1.13
Max Width (cm)	11.09133±0.656	1.15
Curvature (mm)	126.0233±7.559	11.8

Table 5: Gender Wise Comparison of Various Parameters of Sacrum

Variables	**Mean ± Std. Deviation**		**P-value (CI -95%)**
	Female	**Male**	
LSA (degree)	55.346±3.68	50.759±5.4217	0.014
ASA (degree)	56.215±1.937	58.811±3.569	0.036
BSA (degree)	39.315±5.841	35.552±5.682	0.038
Max Height (cm)	8.953±0.602	10.117±1.091	0.001
Max Width (cm)	11.5323±0.600	10.754±0.480	0.003
Curvature (mm)	129.4±5.7373	123.441±7.907	0.044