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A computed tomography-based assessment of the anatomical parameters concerning S2-alar iliac screw insertion in Indian population using "safe trajectory method"

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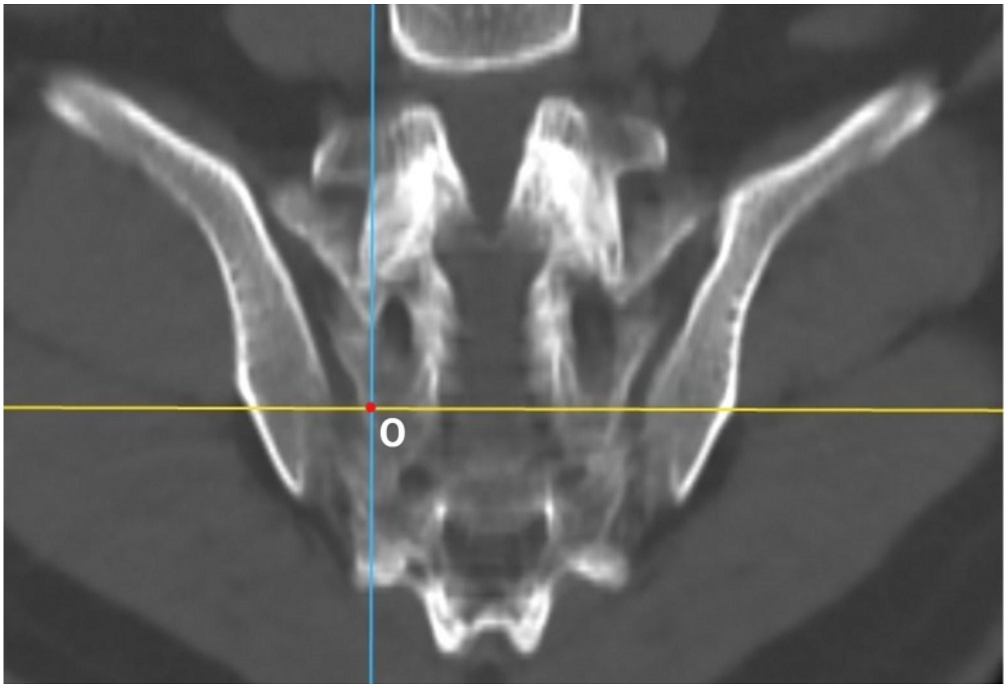
Keywords:	S2 alar iliac screw, Indian population, safe trajectory, Computed tomography

Table 1: Distribution of measuring parameters between the right side and left side for each gender (N=112)

Parameters (Mean ± SD)	Males (N = 58)			Females (N = 54)		
	Right side	Left side	P value	Right side	Left side	P value
Sagittal angle	31.25 ± 6.58	31.04 ± 6.70	0.476	38.02 ± 6.06	37.28 ± 6.14	0.114
Transverse angle	34.91 ± 3.31	34.96 ± 3.53	0.814	36.87 ± 3.64	36.86 ± 3.33	0.935
Maximum length [mm]	112.86 ± 7.65	112.83 ± 7.62	0.868	105.72 ± 7.76	106.00 ± 7.54	0.233
Sacral length [mm]	27.28 ± 3.82	27.22 ± 3.58	0.700	25.41 ± 3.72	25.34 ± 3.69	0.710
S2 midline distance [mm]	29.08 ± 2.62	29.32 ± 5.62	0.730	29.66 ± 2.29	29.42 ± 2.65	0.570
Skin distance [mm]	42.66 ± 15.20	42.76 ± 15.19	0.642	52.48 ± 16.75	52.20 ± 16.73	0.223
Iliac width [mm]	14.77 ± 2.88	14.92 ± 2.75	0.323	12.53 ± 2.32	12.46 ± 2.21	0.580
Sciatic notch distance [mm]	16.34 ± 2.52	16.19 ± 2.45	0.450	16.49 ± 2.28	16.15 ± 1.93	0.109

Table 2: Comparison of measured parameters between gender [males versus females]

Parameters (Mean ± SD)	Right side			Left side		
	Males	Females	P value	Males	Females	P value
Sagittal angle	31.25 ± 6.58	38.02 ± 6.06	<0.001	31.04 ± 6.70	37.28 ± 6.14	<0.001
Transverse angle	34.92 ± 3.31	36.87 ± 3.64	<0.001	35.03 ± 3.54	36.78 ± 3.34	<0.001
Maximum length [mm]	112.86 ± 7.65	105.71 ± 7.76	<0.001	112.83 ± 7.62	106.00 ± 7.54	<0.001
Sacral length [mm]	27.28 ± 3.82	25.41 ± 3.72	<0.001	27.22 ± 3.58	25.34 ± 3.69	<0.001
S2 midline distance [mm]	29.08 ± 2.62	29.66 ± 2.29	0.218	29.32 ± 5.62	29.42 ± 2.65	0.902
Skin distance [mm]	42.66 ± 15.20	52.90 ± 16.63	<0.001	42.76 ± 15.19	52.20 ± 16.73	<0.001
Iliac width [mm]	14.77±2.88	12.53±2.32	<0.001	14.92 ± 2.75	12.46 ± 2.21	<0.001
Sciatic notch distance [mm]	16.34±2.52	16.49±2.28	0.750	16.19 ± 2.45	16.15 ± 1.93	0.924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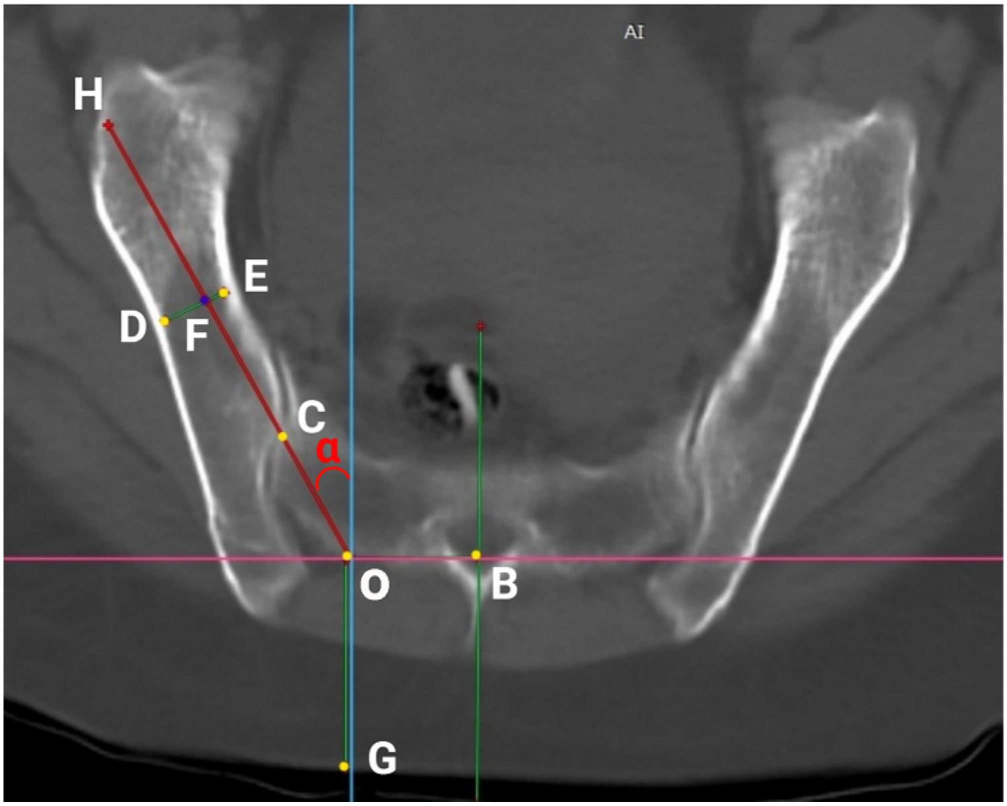
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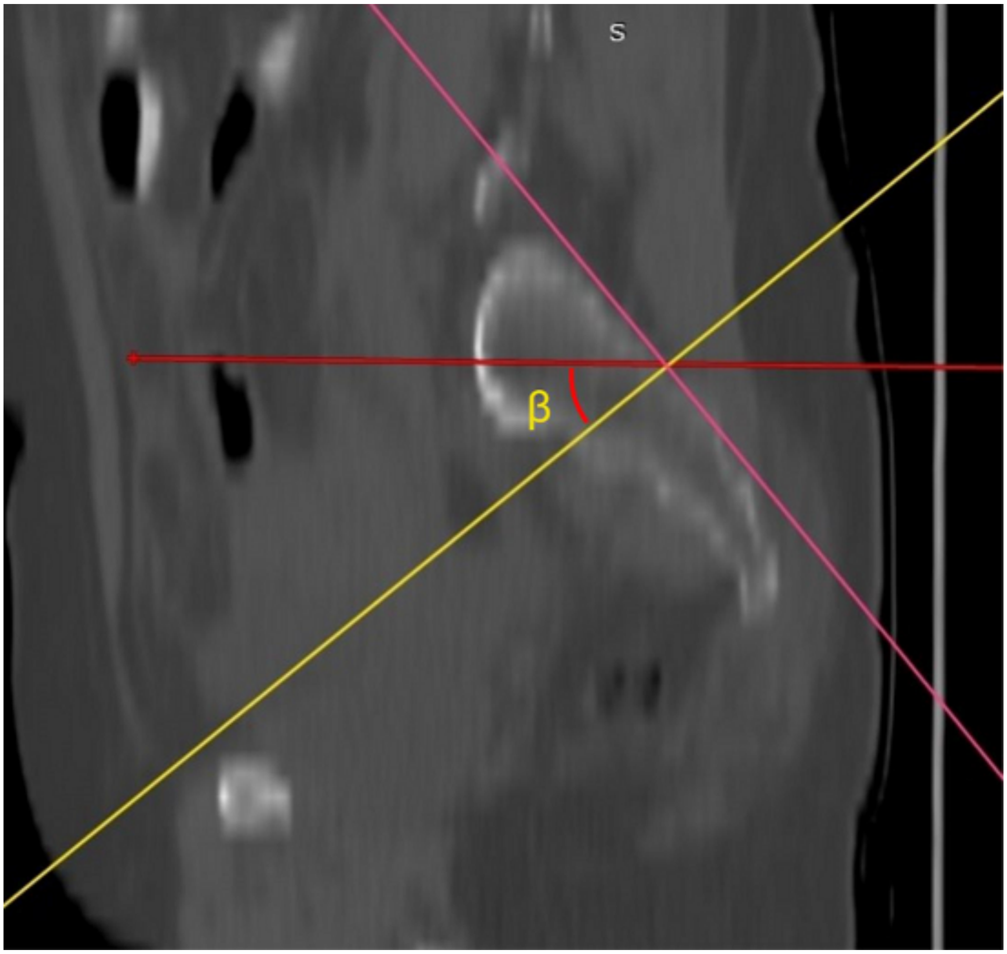
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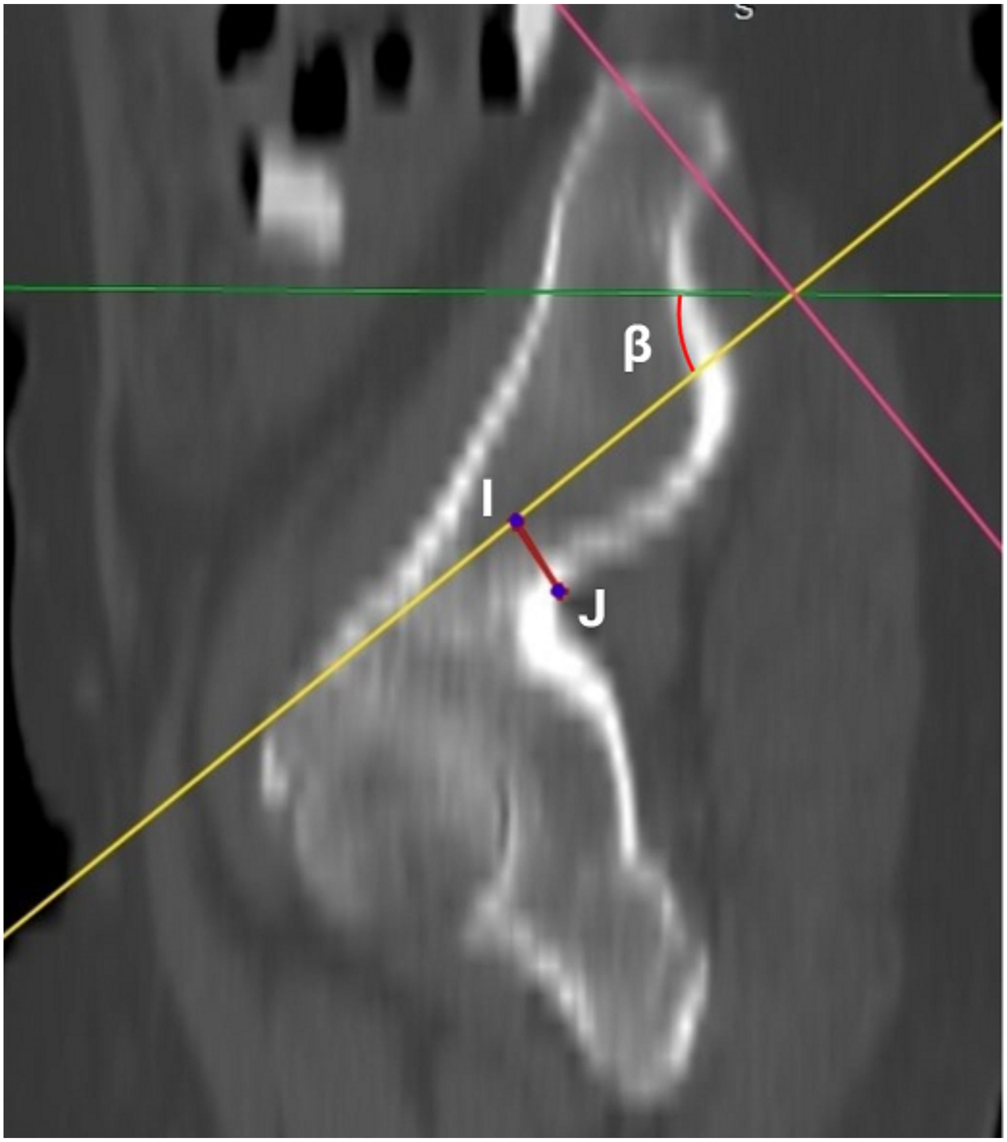
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Abstract

Study design: A retrospective computed tomography (CT)-based radiological analysis.

Purpose: To obtain CT-based morphometric data for S2 alar iliac [S2AI] screw in the Indian population presenting to our tertiary care institution, following the "safe trajectory" concept proposed by Pontes et al in a recently published study.

Overview of Literature: Although prior CT-based morphometric studies regarding S2AI screw have been published for populations of various ethnic groups, there remains a paucity of morphometric data exclusively concerning the Indian population.

Methods: We performed a retrospective CT analysis of 112 consecutive patients using 3D multiplanar reformatting (MPR) software following our exclusion criteria, which were done for various abdominal and pelvic pathologies. CT imaging planes were rotated at a level between S1 and S2 foramen until it corresponded to the ideal S2AI screw trajectory, represented by the greatest length and width of the iliac osseous channel seen in the axial CT section. Subsequently following the concept of safe trajectory, S2AI screw morphometric parameters along corresponding axial and sagittal CT images were measured on both sides of the pelvis.

Results: Females had significantly more screw trajectory angulation in both sagittal and transverse planes on both sides of the pelvis than males [P value<0.001]. Males had significantly more iliac width, maximum screw trajectory length and intrasacral length than females on both sides of the pelvis [P value<0.001]. The S2AI screw entry point in females was significantly more deep-seated from the skin margin than males on both sides of the pelvis [P value<0.001].

Conclusions: Based on our methodology we found that S2AI screw trajectory is significantly more caudal and lateral in females, maximum screw length independent of gender is sufficient for use in the actual clinical practice, and with feasibility of 8.5 mm or even more screw diameter in the majority of the Indian population

Key words: S2 alar iliac screw, Indian population, safe trajectory, Computed tomography

INTRODUCTION

The lumbosacral junction is a complex anatomical region with significantly high shear forces posing an enormous challenge for long spinal fusion procedures extending across it, resulting in significant complications including pseudoarthrosis and implant failure [1]. Indications for spinopelvic fixation involving lumbosacral junction include high-grade spondylolisthesis, long spinal fusion procedures for pediatric or adult spinal deformities due to various causes especially with pelvic obliquity, three-column corrective lumbar osteotomies, lumbopelvic trauma, pseudoarthrosis because of prior surgery, and after performing lower lumbar spine spondylectomy or sacrectomy for tumors or infections [2].

In the existing literature variety of techniques have been described for spinopelvic fixation throughout the years but currently, the iliac screw [IS] and S2 alar iliac screw [S2AI] is most commonly performed. Although the IS placed at the level of posterior-superior iliac spine [PSIS] provides significant pull-out strength, considerable soft tissue dissection is required for screw insertion along with the need of the offset connector for attachment to the spinal construct rod resulting in an increased risk of wound complications and hardware prominence [3]. To overcome these shortcomings of the IS, Sponseller and Kebaish in 2007 proposed the S2AI screw technique [4]. The advantages of this technique are that S2AI insertion at the level second sacral segment is in line with the S1 pedicle screw, thus resulting in less soft tissue dissection and obviating the need of a lateral offset connector. The placement of S2AI is much deeper than the IS, resulting in decreased incidence of hardware prominence, wound dehiscence, and postoperative pain [5].

Although in the existing literature computed tomography [CT] based morphometric data concerning S2AI screw insertion technique has been published about American, Asian and Brazilian populations, there remains a paucity of data exclusively focused on the Indian population [6-11]. In the existing literature, studies have highlighted the fact that a patient's ethnicity may influence the trajectory and length of the S2AI screw [12]. Prior studies evaluated S2AI screw morphometric data based on ideal screw trajectory, which represented the greatest length and width of the iliac osseous channel obtained following rotation of CT image planes [6-8,10,11]. Recently Pontes et al proposed the idea of a safe S2AI screw trajectory to prevent cortical violation of iliac wings which may lead to catastrophic neurovascular complications. The safe trajectory represents the axis of the S2AI screw path with reference to inner iliac cortex at the iliac width region which corresponds to the narrowest portion of the iliac wing, at a distance equal to half the internal diameter of the chosen screw [13]. We prefer to support their concept and using this as an integral part of our methodology, a CT-based evaluation was conducted at our institution with an aim to measure morphometric parameters concerning S2AI screw in the Indian population.

Material & methods

Prior ethical committee approval was obtained at our institute before conducting the present study [SU/SMS&R/76-A/2021/93]. A retrospective review of CT scans conducted from December 2019 to March 2020 for patients with various abdominal and pelvic pathologies was performed. Image data which was used for the present study were anonymized. As it was a retrospective study, it was not possible to obtain informed consent and a waiver for it was taken from our institute ethical committee. Data of 112 consecutive patients were collected following our exclusion criteria which included age less than 18 years, prior surgery involving pelvis or lumbosacral region, transitional lumbosacral anomalies, any prior sacropelvic segment pathology (trauma, infection, tumor, congenital abnormality, ankylosing spondylitis), and any pelvic deformity. All CT images of each patient were retrieved from PACS (Picture Archiving and Communication System) and reviewed by Radiant DICOM viewer software (version 72 5.0.0.219060), and further analysis was done using a dedicated window for bone structures. As per prior published studies, initially images along sagittal and coronal planes for pelvis were reconstructed using 3D multiplanar reformatting (MPR) software function. Next, the CT imaging plane was moved along mid-sagittal reconstruction image to a point between S1 and S2 foramen, with the guidance of coronal image to localize the level. Subsequently, the CT image plane along the sagittal axis was rotated until it corresponded to the ideal S2AI screw trajectory, represented by the greatest length and width of the iliac osseous channel seen in the axial CT image at that level. The entry point of the S2AI screw was marked along the posterior sacral cortex in the axial CT image, which was aided by the coronal plane image in localizing the point [Fig IA & 1B][13]. As per the existing literature, we chose the screw entry point at the junction of two lines: first along the lateral sacral crest, second along the middle of S1 and S2 foramen [14]. Next, the iliac width which determines the largest possible screw diameter was marked, represented by the narrowest distance between the inner and outer cortex of the iliac wing. Following the concept of safe trajectory, a point was marked along the iliac width line with reference to inner iliac cortex and the distance between these two points was equal to half the inner diameter of the chosen screw [13]. We chose screw diameters of 6.5 mm, 7.5 mm, and 8.5 mm for measurement purposes as they are commonly used as per existing literature [15]. Depending upon the iliac width, screw diameter was chosen: 6.5 mm screw for width < 7.5 mm, 7.5 mm screw for width ≥ 7.5 mm but < 8.5 mm, and 8.5 mm screw for width ≥ 8.5mm. Finally, screw trajectory directed toward the anterior iliac cortex was marked between two points, posterior S2 sacral cortex entry point and point along the iliac width line, and the following parameters were measured as follows [Fig. 1B – 1D]:

1. Sagittal angle [β]: caudal angle between screw trajectory along the sagittal plane and horizontal line.
2. Transverse angle [α]: angle between lateral screw trajectory and median line along the axial plane.
3. Maximum length [OH]: maximum length of screw trajectory along the axial plane from the posterior sacral cortex entry point to the anterior iliac cortex.
4. Sacral length [OC]: length of intrasacral screw trajectory along the axial plane.
5. Iliac width [ED]: narrowest iliac wing portion represented by the shortest distance between the inner and outer iliac wing cortex.
6. S2 midline distance [OB]: distance between the posterior sacral screw entry point and line along the middle of S2 vertebrae.
7. Skin distance [OG]: distance between the posterior sacral screw entry point and skin margin.
8. Sciatic notch distance [IJ]: minimum distance between greater sciatic notch and screw trajectory along the sagittal plane.

CT-based morphometric measurements of above mentioned S2AI screw parameters were independently performed by a senior spinal surgeon and a senior radiologist, and subsequently average of measurements noted by two reviewers was recorded. Following it the recorded data were subjected to statistical analysis using IBM SPSS Statistics for Mac, Version 25.0., IBM Corp., Chicago, IL. Descriptive statistics were reported as mean (SD) for continuous variables. Paired t-test was used to find the statistically significant difference between the right and left sides within each gender. An independent t-test was used to find the differences in parameters between males and females. P-value < 0.05 indicated a significant difference for all the statistical data analyses.

RESULTS

The present study assessed CT records of 112 patients, 58 [51.8%] were males and 54 [48.2%] were females. The mean age was 36.79 years [SD 13.67, range 18 -- 77 years]. As shown in Table 1, the results indicated no significant differences between the right and left sides with regard to measured parameters within each gender. On analyzing morphometric data between genders as shown in Table 2, measured sagittal plane angulation of S2AI screw trajectory in females [Right: 38.02 ± 6.06; Left: 37.28 ± 6.14] was significantly more than males [Right: 31.25 ± 6.58; Left: 31.04 ± 6.70] [p value<0.001]. In the transverse plane also, lateral angulation of screw trajectory in females [Right: 36.87 ± 3.64; Left: 36.78 ± 3.34] was significantly more than males [Right: 34.92 ± 3.31; Left: 35.03 ± 3.54] [p value<0.001]. With regard to length parameters of screw trajectory involving maximum length [OH] and intrasacral length [OC], both parameters were significantly more in men [OH, right: 112.86 ± 7.65; left: 112.83 ± 7.62] [OC, right: 27.28 ± 3.82; left: 27.22 ± 3.58] in comparison to females [OH, right: 105.71 ± 7.76; left: 106.00 ± 7.54] [OC, right: 25.41 ± 3.72; left: 25.34 ± 3.69] [p value<0.001]. The iliac width was significantly narrower in females [Right: 12.53±2.32; Left: 12.46 ± 2.21] on comparison to males [Right: 14.77±2.88; Left: 14.92 ± 2.75] [p value<0.001]. The screw entry point was significantly more deep seated from the overlying skin margin in females [Right: 52.90 ± 16.63; Left: 52.20 ± 16.73] on comparison to males [Right: 42.66 ± 15.20; Left: 42.76 ± 15.19] [p value<0.001]. However, there was no significant difference on both sides regarding the midline distance of the screw entry point and sciatic notch distance among genders.

DISCUSSION

About any surgical technique, a prior thorough anatomical knowledge helps the surgeon to improve their surgical skills and minimize the complications [16]. Prior morphometric studies regarding various spinal parameters have highlighted significant differences between the Indian population and other ethnic populations [17,18]. Even concerning S2AI screw, Katsuura et al proposed that patient's ethnicity may have an influence on screw trajectory and length [12]. Based on these facts and the lack of any data exclusively focused on the Indian population in the existing literature, we decided to evaluate morphometric data regarding S2AI insertion.

Major risks involved with the S2AI screw technique results from iliac cortical violation, either from the oversize screw channel or the over-tilted screw trajectory especially at the iliac width region which represents the narrowest portion of the iliac wing. This may lead to catastrophic complications like visceral injuries involving intestines and urogenital organs, and neurovascular injuries involving internal iliac vessels, superior gluteal artery, lumbosacral plexus, obturator nerve, and sciatic nerve [19]. To obviate such serious complications, Pontes et al have proposed the concept of safe trajectory which we adopted for our present morphometric study regarding S2AI screw in the Indian population [13]. We believe that the distance between the inner iliac cortex and screw trajectory at the iliac width region, which is equivalent to half the diameter of the chosen screw will provide a safety margin in preventing cortical violation resulting in catastrophic complications.

On comparing the iliac width measurements with data from other ethnic populations, our study results showed narrower width in comparison to Chinese (Zhu et al, Right 17 ± 2.81/ Left 16.98 ± 3.52 in males and Right 14.94 ± 2.60/ Left 14.76 ± 2.46 in females; Xu et al, Right 17.8 ± 3.3/ Left 17.5 ± 3.4 in males and Right 15.5 ± 2.9/ Left 15.3 ± 2.6 in females), Japanese (Yamada et al, Right 18.5 ± 3.7/ Left 18.1 ± 3.4 in males and Right 16 ± 3.1/ Left 15.9 ± 2.8 in females) and Brazilian population (Junior et al, 17.94 ± 2.34) [7,8,10,11]. In the present study considering gender differences for the iliac width, men had a wider width than females, similar to the pattern seen in the Chinese and Japanese populations [7,8,11]. As per prior existing literature, three screw diameters depending upon iliac width were chosen for measurement purposes, which included 6.5 mm, 7.5 mm, and 8.5mm as the largest diameter [15]. Only 3.57 % of cases

(3 females and one male) of our study population had an inadequate iliac width for 8.5 mm screw diameter. As per prior studies, the bending strength of a screw increases proportionately to its radius to the fourth power. Although there exists no recommendation for ideal S2AI screw diameter regarding the adult population in current literature, for the pediatric population Jain et al proposed the ideal diameter to be > 8mm for preventing screw fracture. Based on our study results regarding the iliac width (average 14 mm in males and 12 mm in females), our opinion is that a screw diameter of 8.5 mm and even more may be feasible in the majority of the Indian population [20].

Concerning maximum screw trajectory length, our study results were shorter than screw length seen in Chinese (Zhu et al, Right 120.63 ± 7.54/ Left 121.25 ± 8.33 in males and Right 115.67 ± 8.24/ Left 114.75 ± 9.44 in females; Xu et al, Right 121.2 ± 8.8/ Left 121.4 ± 9.3 in males and Right 114.2 ± 8.7/ Left 114.3 ± 9.5 in females), Japanese (Yamada et al, Right 121.8 ± 10.1/ Left 121.5 ± 10.3 in males and Right 112.7 ± 9.1/ Left 113.8 ± 9.6 in females) and Brazilian population (Junior et al: 133.67 ± 9.89) [7,8,10,11]. Considering gender differences, men had significantly more screw length in comparison to females in our study, similar to the pattern seen in the Chinese and Japanese populations [7,8,11]. The difference in maximum screw length in our study compared to other ethnic populations may be related to our study methodology, resulting in drifting away of screw trajectory from the inner iliac cortex by a distance equal to half the inner screw diameter of the chosen screw depending upon the iliac width for preventing cortical violation. As pointed by Pontes et al, the closer the screw trajectory is to the inner iliac cortex in the axial plane longer will be the screw length [13]. The average screw length in our study was 112 mm for men and 106 mm for females, which still exceeds the screw length (approximately 50 – 75 mm) commonly chosen by surgeons in clinical practice as per the existing literature [21]. As per O'Brien et al study regarding the biomechanical evaluation of S2AI screw, the authors concluded that the 65 mm length S2AI screw is biomechanically equivalent to 90 mm IS and 80 mm S2AI screw. The plausible reason proposed by them was that the IS trajectory primarily passes through the spongy iliac bone, whereas the S2AI screw trajectory involves cortical penetration of the sacroiliac joint resulting in additional strength despite its smaller length [22]. In our opinion, a possible trade-off for screw length versus screw safety is worth consideration, which can be further verified by clinical-based studies in the future.

On comparing sagittal angulation of S2AI screw trajectory, our study results were more than Chinese (Zhu et al, Right 29.96 ± 8.28/ Left 29.15 ± 8.60 in males and Right 35.72 ± 7.53/ Left 34.5 ± 6.56 in females; Xu et al, Right 29 ± 7.4/ Left 28.3 ± 7.7 in males and Right 34.8 ± 7.1/ Left 33.9 ± 6.5 in females), Japanese (Yamada et al, Right 28 ± 7.2/ Left 27.5 ± 6.8 in males and Right 33.9 ± 6.6/ Left 33.4 ± 6.4 in females) and Brazilian population (Junior et al: 29.92 ± 2.33) [7,8,10,11] . Considering gender differences, females had more sagittal angulation than males similar to the pattern seen in the Chinese and Japanese populations [7,8,11]. The difference in sagittal plane screw angulation as compared to other ethnic populations again reinforces the fact, that patient's ethnicity influences the screw trajectory, as also highlighted by prior studies [12].

About transverse angulation of S2AI screw trajectory, the study by Yamada et in the Japanese population (Right 37.7 ± 7.5/ Left 37.9 ± 7 in males and Right 32.4 ± 7.1/ Left 32.8 ± 7.6 in females) and Xu et al in the Chinese population (Right 38.4 ± 5.3/ Left 37.8 ± 4.7 in males and Right 34.4 ± 5.1/ Left 34.1 ± 5.9 in females) showed men to have significantly more transverse angulation than females, although another Chinese population study by Zhu et al (Right 37.16 ± 3.14/ Left 36.49 ± 3.14 in males and Right 36.27 ± 3.27/ Left 35.72 ± 3.76 in females) and study by Junior et al in Brazilian population (33.91± 2.20) showed no significant gender difference regarding S2AI screw transverse angulation [7,8,10,11]. In our study, females had significantly more transverse angulation than males which differed from prior published studies result involving other ethnic populations. As per our study methodology, three variables might influence transverse screw trajectory: midline location of screw entry point, iliac width, and distance of point along iliac width with reference to inner iliac cortex depending upon chosen screw diameter. No significant gender difference was seen regarding midline distance of screw entry point and in almost all our study population 8.5 mm screw diameter was chosen irrespective of gender, negating their influence on the transverse screw trajectory. The transverse screw trajectory passed more laterally in females than males at the level of iliac width, as they had a significantly narrower width than males, thus explaining the resulting pattern seen in our study.

As per the recommendation of prior studies regarding the distance between screw trajectory and greater sciatic notch along the sagittal plane, it should be within 20 mm resulting in primarily cortical bony purchase for the S2AI screw and increasing its stability [23]. Our study results regarding sciatic notch distance were as per prior recommendations and no significant gender difference was noted, similar to study results by Liu et al (Right 16.23 ± 2.75/ Left 15.78 ± 3.46 in males and Right 17.16 ± 2.87/ Left 16.77 ± 2.94 in females) in Chinese population [14]. About S2AI screw skin distance, females had significantly more screw depth from the skin than males as per present study results, contrary to prior published studies for different ethnic populations [8,10]. The explanation may be in accordance with reasons put forward by prior studies, which we also believe that lumbopelvic patterns vary according to race, sex, skeletal maturity, and age resulting in differences for S2AI screw morphometric parameters [12]. The present study has its limitations. As the reference lines for assessing anatomical parameters were established subjectively, this may have resulted in some element of error in our measurements. The present study population included those with relatively healthy spine without any pelvic deformity, whereas spinopelvic fixation is usually performed in patients with major spinal deformities including the pelvic region. In the present study, 8.5 mm screw diameter was the maximum which we considered for anatomical measurements. If screw diameter > 8.5 mm is considered, then the morphometric measurements regarding the S2AI screw may vary. We did not focus on spinopelvic parameters influence on S2AI screw measurements as highlighted by recent Vivace et al study, who proposed an inverse relationship between pelvic tilt and cephalocaudal S2AI screw trajectory [24]. The present study population included those primarily from northern India, which may not represent the full spectrum of India's ethnic diversity. However, despite these limitations, this is the first CT-based morphometric study regarding S2AI screw based on the "safe trajectory method"in the Indian population.

CONCLUSION

In our knowledge, this is the first CT-based study assessing S2AI screw morphometric parameters using the "safe trajectory method", exclusive to the Indian population. Based on our methodology we found that S2AI screw trajectory is significantly more caudal and lateral in females than males, maximum screw length independent of gender is sufficient for use in the actual clinical practice, and with feasibility of 8.5

mm or even more screw diameter in the majority of the Indian population. Additional multicentric studies concerning S2AI screw insertion in the Indian population including clinically-based ones, may help to consolidate and expand the morphometric data obtained from the present study.

REFERENCES

1. Harris A, Kebaish KM. (2019). Sacropelvic fixation: An overview and update on current techniques. Semin Spine Surg, 31(2), 81-86. doi.org/10.1053/j.semss.2019.03.006

2. Nanda A, Maghwani J, Kluger PJ. (2020). Sacropelvic fixation techniques - Current update. J Clin Orthop Trauma, 11(5), 853-862. doi: 10.1016/j.jcot.2020.07.022.

3. El Dafrawy MH, Raad M, Okafor L, Kebaish KM. (2019). Sacropelvic Fixation: A Comprehensive Review. Spine Deform. ,7(4):509-516. doi.org/10.1016/j.jspd.2018.11.009.

4. Sponseller PD. (2007). The S2 portal to the ilium. Semin Spine Surg., 2(2), 83-87.

5. Jain A, Brooks JT, Kebaish KM, Sponseller PD. (2016). Sacral Alar Iliac Fixation for Spine Deformity. JBJS Essent Surg Tech., 6(1), e10(1-8). doi:10.2106/JBJS.ST.15.00074.

6. Chang TL, Sponseller PD, Kebaish KM, Fishman EK. (2009). Low profile pelvic fixation: anatomic parameters for sacral alar-iliac fixation versus traditional iliac fixation. Spine (Phila Pa 1976), 34(5),436-40. doi: 10.1097/BRS.0b013e318194128c.

7. Li C, Xu X, Xu J, Tan J, Wu W. (2019). Safe regulable angle and optimum trajectory of the second sacral alar iliac screw: a digital simulation study. Int J Clin Exp Med.,12(5), 5661-5667.

8. Zhu F, Bao HD, Yuan S, Wang B, Qiao J, Zhu ZZ, et al., (2013). Posterior second sacral alar iliac screw insertion: anatomic study in a Chinese population. Eur Spine J., 22(7), 1683-9. doi: 10.1007/s00586-013-2734-4.

9. Kwan MK, Jeffry A, Chan CYW, Saw LB. (2012). A radiological evaluation of the morphometry and safety of S1, S2 and S2-ilium screws in the Asian population using three-dimensional computed tomography scan: an analysis of 180 pelvis. Surg Radiol Anat., 34(3), 217-27. doi: 10.1007/s00276-011-0919-2.

10. Junior MCMT, Souza JPVD, Araujo TPF, Marcon RM, Cristante AF, Filho TEPDB, et al. (2019). Comparative tomographic study of the S2-alar-iliac screw versus the iliac screw. Eur Spine J., 28(4), 855-862. doi: 10.1007/s00586-018-5806-7.

11. Yamada K, Higashi T, Kaneko K, Ide M, Sekhiya T, Saito T. (2017). Optimal trajectory and insertion accuracy of sacral alar iliac screws. Acta Orthop Traumatol Turc., 51(4), 313-318. doi:10.1016/j.aott.2017.05.004.

12. Katsuura Y, Chang E, Sabri SA, Gardner WE, Doty JF. (2018). Anatomic Parameters for Instrumentation of the Sacrum and Pelvis: A Systematic Review of the Literature. Acad Orthop Surg Glob Res Rev., 2(8), e034. doi:10.5435/JAAOSGlobal-D-18-00034.

13. Pontes MDDS, Ismael LK, Francisco LA, Herrero CFPDS. (2020). Description of the Sacropelvic Parameters Measurement Method for S2-alar iliac Screw Insertion. Rev Bras Ortop (Sao Paulo)., 55(6), 702-707. doi: 10.1055/s-0040-1713163.

14. Liu F, Yang Y, Wen C, Guo L, Wang A, Huang W, et al. (2019). Morphometric measurement and applicable feature analysis of sacral alar-iliac screw fixation using forward engineering. Arch Orthop Trauma Surg., 140(2), 177-186. doi: 10.1007/s00402-019-03257-w.

15. Wu AM, Chen D, Chen CH, Li YZ, Tang L, Phan K, et al. The technique of S2-alar-iliac screw fixation: a literature review. (2017). AME Med J., 2(179), 1-8. doi.org/10.21037/amj.2017.12.02.

16. Chen, X., Chen, J., & Zhang, F. (2019). Imaging anatomic research of oblique lumbar interbody fusion in a Chinese population based on magnetic resonance. World Neurosurgery, 128, e51–e58. doi.org/10.1016/j.wneu.2019.03.244.

17. Acharya, S., Dorje, T., & Srivastava, A. (2010). Lower dorsal and lumbar pedicle morphometry in Indian population: a study of four hundred fifty vertebrae. Spine (Phila Pa 1976), 35(10), E378–E384. doi.org/10.1097/BRS.0b013e3181cb7f2b.

18. Srivastava, A., Nanda, G., Mahajan, R., Nanda, A., Batra, S., Mishra, N., et al. (2019). Feasibility of sub-axial cervical laminar screws, including C7, in the Indian population: a study on 50 patients using computed tomography-based morphometry measurements. Asian Spine Journal, 13(1), 7–12. doi.org/10.31616/asj.2018.0110.

19. Jabbar AA, Yilmaz E, Iwanaga J, Tawfik T, O'Lynnger TM, Schildhauer TA, et al. (2018). Neurovascular Relationships of S2AI Screw Placement: Anatomic Study. World Neurosurg., 116, e108-e112. doi: 10.1016/j.wneu.2018.04.095.

20. Jain A, Kebaish KM, Sponseller PD. (2016). Sacral-Alar-Iliac Fixation in Pediatric Deformity: Radiographic Outcomes and Complications. Spine Deform., 4(3), 225-229. doi: 10.1016/j.jspd.2015.11.005.

21. Peelle MW, Lenke LG, Bridwell KH, Sides B. (2006). Comparison of pelvic fixation techniques in neuromuscular spinal deformity correction: Galveston rod versus iliac and lumbosacral screws. Spine (Phila Pa 1976), 31(20), 2392-8. DOI: 10.1097/01.brs.0000238973.13294.16

22. O'Brien JR, Yu W, Kaufman BE, Bucklen B, Salloum K, Khalil S, et al. (2013). Biomechanical evaluation of S2 alar-iliac screws: effect of length and quad-cortical purchase as compared with iliac fixation. Spine (Phila Pa 1976), 38(20), E1250-5. DOI: 10.1097/BRS.0b013e31829e17ff.

23. Moshirfar A, Kebaish KM, Riley III LH. (2009). Lumbosacral and Spinopelvic Fixation in Spine Surgery. Semin Spine Surg., 21,55-61. doi:10.1053/j.semss.2008.12.002.

24. Vivace BJ, Laratta JL, Gum JL, Shillingford JN, Dimar JR, Glassman SD, et al. (2020). Pelvic parameters directly influence ideal S2 alar-iliac (S2AI) screw trajectory. NASSJ, 2,100014. doi.org/10.1016/j.xnsj.2020.100014.

Figure legend:

Figure 1: Reconstructed CT images using 3D MPR function following sagittal plane axis rotation to achieve ideal screw trajectory. 1A: coronal plane CT image with point “O” as a screw entry point; 1B: axial plane CT image with point “O” as screw entry point corresponding with the coronal plane image. α: transverse plane angle of screw trajectory, OH: maximum screw trajectory length, OC: sacral distance, OB: S2 midline distance, ED: iliac width, EF: represent distance equal to half the internal diameter of the chosen screw; IC & ID represent sagittal plane images. β: sagittal plane angle of screw trajectory, IJ: sciatic notch distance.