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A retrospective CT based comparative analysis of available screw pathways to determine optimal iliac screw trajectory

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Abstract

Introduction: The lumbo-sacral stabilization using iliac screw is gaining popularity in such cases of long multi segment lumbar constructs. Iliac screws help to achieve strong spinopelvic fixation, augments and protects sacral screws. However, there is a great variability found in literature for iliac screw fixation in terms of trajectory, screw length and screw diameter. Also, to the best of our knowledge, there is lacunae in current literature regarding the optimal pathway, screw length and screw diameter in the Indian population. Hence, we planned the study with the aim to analyze the available screw pathways to determine optimal iliac screw trajectory, screw length and diameter for the Indian population.

Material and methods: This was a tertiary center-based retrospective study. One hundred pelvic CT scans of patients in 18-70 years age, who underwent abdominal CT on Siemens 256-slice dual source CT scanner for various indications were evaluated. Subsequently, 4 iliac screw trajectories were assessed by connecting the points given below using double oblique reformats on which the lengths and narrowest zones of these trajectories were measured. Path A: Posterior Superior Iliac Spine (PSIS) to Anterior Superior Iliac Spine (AIIS); Path B: point between PSIS and posterior inferior iliac spine (PIIS) to Anterior Inferior iliac spine (AIIS); Path C: iliac crest intersection point (CLIC) point to Upper acetabulum; Path D: CLIC point to acetabular center.

Results: Statistically significant difference was found in the lengths of various pathways. Path A (PSIS to AIIS) was found to be the longest (mean 13 cm). The second longest path in our study was path C (CLIC point to Upper acetabulum). The narrowest widths of each path were not found to have any statistically significant difference.

Conclusion: Iliac screw fixation is of paramount importance for lumbosacral stabilization. Of the studied paths, trajectory from posterior-superior iliac spine to Antero-inferior iliac spine has the longest passage length and is the most optimal path for the Indian population. In case additional screws are required, the trajectory from CLIC point to Upper acetabulum provides the second largest screw passage.

Key words: iliac screw trajectory, lumbo-sacral fixation, iliac screw, spinal fixation

Introduction

Lumbo-sacral stabilization using iliac screws has gained popularity as an effective technique for achieving strong spinopelvic fixation and protecting sacral screws in cases of long multi-segment lumbar construct [1,2]. However, the literature exhibits considerable variability regarding the optimal trajectory, screw length, and diameter for iliac screw fixation [3-7]. These variations pose challenges for surgeons in selecting the most appropriate parameters, potentially leading to suboptimal outcomes and complications [8-10]. Moreover, there is a notable gap in the current literature regarding the optimal iliac screw pathway, length, and diameter specifically for the Indian population [11].

The Indian population exhibits distinct anatomical characteristics compared to other populations, including differences in pelvic morphology, bone density, and body habitus [12]. These unique features necessitate a thorough understanding of the optimal iliac screw parameters tailored to the Indian population. However, the existing literature predominantly comprises studies conducted in non-Indian populations, limiting their applicability and relevance to the Indian context [13].

The lack of specific research addressing the optimal iliac screw parameters in the Indian population creates a significant gap in knowledge and hampers evidence-based decision-making for surgeons performing lumbo-sacral stabilization procedures [3,4]. This gap can lead to suboptimal outcomes, including inadequate screw purchase, increased risk of screw loosening or failure, and compromised biomechanical stability of the construct.

Hence, the aim of our study is to analyze available screw pathways and determine the optimal iliac screw trajectory, length, and diameter for the Indian population. By conducting a comprehensive analysis of 100 pelvic CT scans, we intend to provide valuable insights into the most effective and appropriate iliac screw parameters for use in lumbo-sacral stabilization procedures in the Indian population.

The findings of our study will have several implications. Surgeons performing lumbo-sacral stabilization surgeries in India can utilize the recommended optimal iliac screw parameters to enhance surgical planning, improve screw placement accuracy, and optimize biomechanical stability. This, in turn, can lead to better clinical outcomes, reduced complications, and improved patient satisfaction.

Moreover, our study will contribute to the existing literature by filling the current knowledge gap regarding the optimal iliac screw parameters specific to the Indian population. This will expand the understanding of iliac screw fixation techniques and provide valuable evidence for future research and advancements in the field of lumbo-sacral stabilization.

Material and methods

This was a tertiary center-based retrospective study. Inclusion criteria were as follows:

1. Patients between the ages of 18 and 70 years.

2. Pelvic CT scans performed on single machine in radiology department - Siemens 256-slice dual-source CT scanner.

3. Patients who underwent abdominal CT for various indications.

Exclusion criteria were as follows:

1. Patients with pelvic deformities: Patients with pre-existing pelvic deformities, such as congenital abnormalities, scoliosis, or other structural anomalies affecting the pelvis, will be excluded. Including such cases could introduce confounding variables and affect the generalizability of the study.

2. Patients with pelvic trauma: Individuals who have undergone pelvic trauma, such as fractures or dislocations, will be excluded. Pelvic trauma can result in significant anatomical changes and alterations in the bone structure, which could impact the trajectory and feasibility of iliac screw fixation. Excluding these cases will ensure that the study focuses on the normal pelvic population.

3. Patients with pelvic tumors: Patients diagnosed with any pelvic tumors, such as primary bone tumors or metastatic lesions, will be excluded. Pelvic tumors can cause structural changes, bone destruction, or pathologic fractures, making the anatomy unsuitable for standard iliac screw fixation. These cases would not represent the normal pelvises targeted by the study.

Based on sample size calculation, One hundred pelvic CT scans of patients in 18-70 years age (mean age 34 years) who underwent abdominal CT on Siemens 256-slice dual source CT scanner for various indications were evaluated. There were 43 female and 57 male pelvises. In order to avoid selection bias, we included all the last 100 scans done on single machine in radiology department that met our inclusion criterion. Orthogonal axial, coronal and sagittal multi planar reformat (MPR) in the bone window and volume rendered technique (VRT) images were viewed alongside on screen in a 2 x 2 format. First, the chaotic line - iliac crest intersection point (CLIC point) was determined by extrapolating the chaotic line (drawn from iliopubic eminence to the anterior most point of the auricular surface of the sacrum) to the posterior iliac crest (Figure 1).

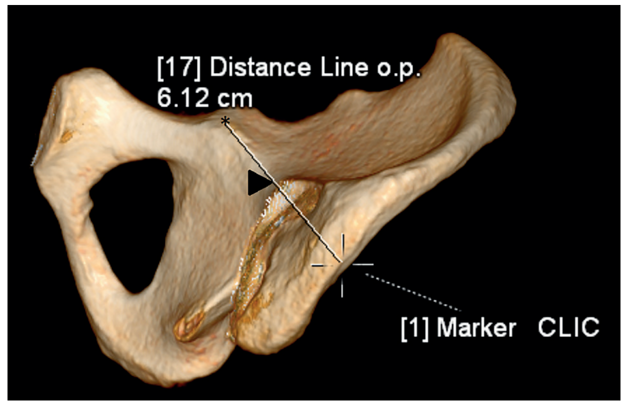

Figure 1 - Volume rendered CT image depicting the chaotic line drawn from iliopubic eminence (*) to the anterior most point of the auricular surface of the sacrum (black arrowhead). Further extrapolation of chaotic line to posterior iliac crest to determine the CLIC point.

The CLIC point, Anterior inferior iliac Spine (AIIS), Posterior superior iliac spine (PSIS), a point between PSIS and posterior inferior iliac spine (PIIS), upper edge of acetabulum and the acetabular center were marked on the VRT image. Subsequently, 4 iliac screw trajectories were assessed by connecting the points as given below to obtain their double oblique reformats. The lengths of these paths, as well as the width of the two narrowest points of cancellous bone were determined. To check the inter- and intraclass correlation coefficient of the measurements, two independent senior residents of Radiology department and Radiology consultant reviewed all data. The measurements were taken three times 2 weeks apart by each of the observer and the means of measured values were used as the final value [1,2]. The four trajectories assessed were as follows:

Path A: PSIS to AIIS (Figure 2-4).

Path B: Point between PSIS and PIIS to AIIS (Figure 5-7).

Path C: CLIC point to upper acetabulum (Figure 8-10).

Path D: CLIC point to acetabular centre (Figure 11-13).

Statistical analysis

Sample size estimation was done based on study of Liu et al. To calculate the sample size for our study with an effect size of 2 m , an alpha level of 0.05, and a power of 80%, we used the following sample size formula.

$n = 2 * [(Z\alpha/2 + Z\beta)^2 * \sigma^2] / \delta^2$

Where:

n = Sample size per group

$Z\alpha/2$ = Critical value for the desired alpha level (two-tailed test)

$Z\beta$ = Critical value for the desired power level

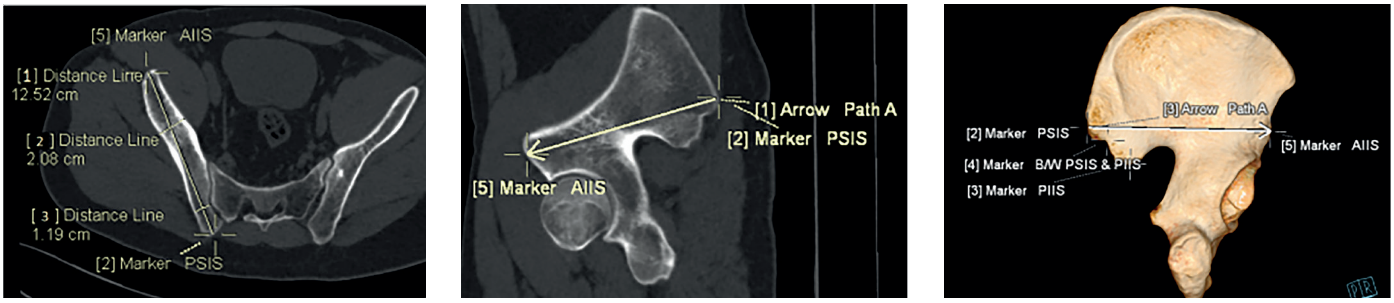

Figure 2a - **Path A [PSIS to AIIS].** Double oblique reformatted CT image showing Path A trajectory; where [1] represents its length, while [2] and [3] represent width of its narrowest zones, [2] being anterior to [3].
Figure 2b. image showing Path A trajectory in sagittal oblique reformatted image.
Figure 2c. image showing Path A trajectory in Volume rendered CT image.

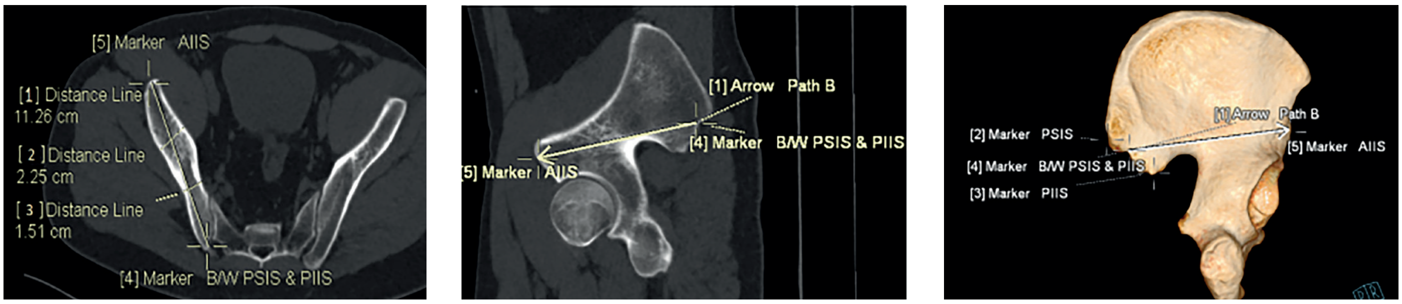

Figure 3a - **Path B [Point between PSIS and PIIS to AIIS].** Double oblique reformatted CT image showing Path B trajectory; where [1] represents its length, while [2] and [3] represent width of its narrowest zones, [2] being anterior to [3].
Figure 3b. Image showing Path B trajectory in sagittal oblique reformatted image.
Figure 3c. Image showing Path B trajectory in volume rendered CT image.

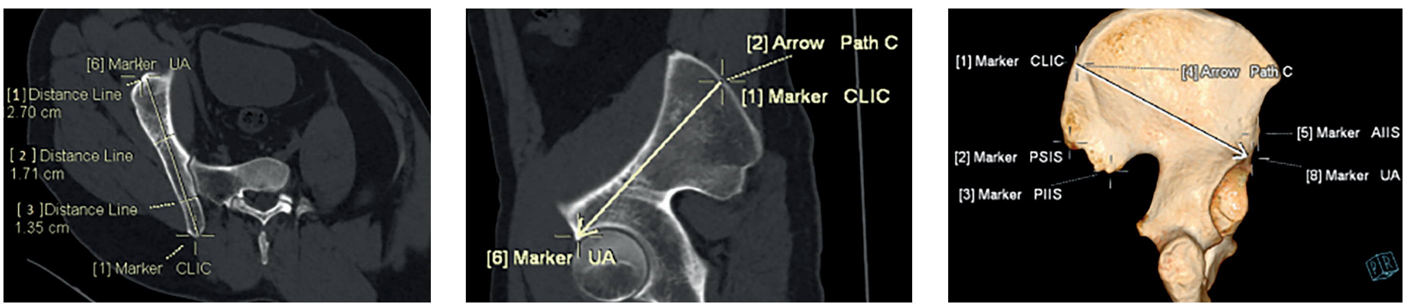

Figure 4a - **Path C [CLIC point to upper acetabulum (UA)].** Double oblique reformatted CT image showing Path C trajectory; where [1] represents its length, while [2] and [3] represent width of its narrowest zones, [2] being anterior to [3].
Figure 4b. Image showing Path C trajectory in sagittal oblique reformatted image.
Figure 4c. Image showing Path C trajectory in volume rendered CT image.

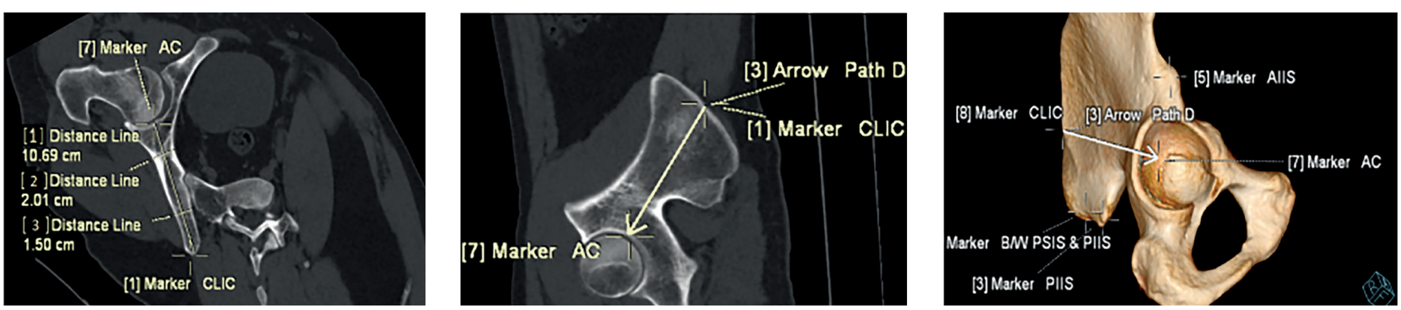

Figure 5a - **Path D [CLIC point to acetabular centre (AC)].** Double oblique reformatted CT image showing Path D trajectory; where [1] represents its length, while [2] and [3] represent width of its narrowest zones, [2] being anterior to [3].
Figure 5b. Image showing Path D trajectory in sagittal oblique reformatted image.
Figure 5c. Image showing Path D trajectory in volume rendered CT image.

σ = Standard deviation of the outcome variable (assumed to be equal for both groups)

δ = Effect size (mean difference)

Substituting these values into the formula we got n=89.8 which is approximately 89. A sample size of 100 was therefore appropriate. SPSS 20.0 software was used for the study. The Shapiro-Wilk test was used for assessing the normality of data. The measured data was within normal distribution and was presented as mean ± standard variation. Independent group t test was used to compare various paths with acceptable alpha error of 5%. The correlation of variables was tested in both groups using Pearson correlation coefficient. p value of less than .05 was considered statistically significant.

Results

Table 1 shows the descriptive analysis of lengths and breadths of each path. All measured paths showed excellent inter- and intraclass agreement. The intra- and interclass correlation coefficients were 0.9 and 0.92 for path A, 0.93 and 0.95 for path B, 0.91 and 0.9 for path C and 0.94 and 0.95 for path D. The lengths of various pathways were found to be statistically significantly different as illustrated in Table 2. Path A (PSIS to AIIS) was found to be the longest (mean 13 cm).The second longest path in our study was path C (CLIC point to Upper acetabulum). The narrowest width of each path were not found to have any statistically significant differences as shown in Table 2. The mean widths of all of the above paths were over 12 mm, thus allowing the thickest iliac screw to be placed comfortably. Thus, Path A (PSIS to AIIS) and path C (CLIC point to Upper acetabulum) were found to be superior to the other paths.

Table 1 The lengths and width of various pathways. Width A and Width B are two narrowest zones in the described paths; width A being anterior to width B.

		N	Mean	Std. Deviation	Std. Error
LENGTH (cm)	PSIS TO AIIS	100	13.0033	.73129	.07313
	BETWEEN PSIS AND PIIS TO AIIS	100	11.8924	.98000	.09800
	CLIC TO UPPER ACETABULUM	100	12.5876	.95383	.09538
	CLIC TO ACETABULAR CENTRE	100	10.9858	.63057	.06306
	Total	400	12.1173	1.13186	.05659
WIDTH A (cm)	PSIS TO AIIS	100	1.6615	.34227	.03423
	BETWEEN PSIS AND PIIS TO AIIS	100	1.6597	.32572	.03257
	CLIC TO UPPER ACETABULUM	100	1.7580	.29424	.02942
	CLIC TO ACETABULAR CENTRE	100	1.6532	.29444	.02944
	Total	400	1.6831	.31665	.01583
WIDTH B (cm)	PSIS TO AIIS	100	1.2382	.27163	.02716
	BETWEEN PSIS AND PIIS TO AIIS	100	1.2544	.35489	.03549
	CLIC TO UPPER ACETABULUM	100	1.2244	.21538	.02154
	CLIC TO ACETABULAR CENTRE	100	1.2880	.24567	.02457
	total	400	1.2512	.27678	.01384

Table 2 The statistical comparison of length and width means of various pathways with p value. Width A and Width B are the two narrowest zones in the described paths.

Dependent Variable	From	To	Std. Error	Sig.
LENGTH	PSIS TO AIIS	BETWEEN PSIS AND PIIS TO AIIS	.11838	.000
		CLIC TO UPPER ACETABULUM	.11838	.003
		CLIC TO ACETABULAR CENTRE	.11838	.000
	BETWEEN PSIS AND PIIS TO AIIS	PSIS TO AIIS	.11838	.000
		CLIC TO UPPER ACETABULUM	.11838	.000
		CLIC TO ACETABULAR CENTRE	.11838	.000
	CLIC TO UPPER ACETABULUM	PSIS TO AIIS	.11838	.003
		BETWEEN PSIS AND PIIS TO AIIS	.11838	.000
		CLIC TO ACETABULAR CENTRE	.11838	.000
	CLIC TO ACETABULAR CENTRE	PSIS TO AIIS	.11838	.000
		BETWEEN PSIS AND PIIS TO AIIS	.11838	.000
		CLIC TO UPPER ACETABULUM	.11838	.000
WIDTH A	PSIS TO AIIS	BETWEEN PSIS AND PIIS TO AIIS	.04453	.968
		CLIC TO UPPER ACETABULUM	.04453	.031
		CLIC TO ACETABULAR CENTRE	.04453	.852
	BETWEEN PSIS AND PIIS TO AIIS	PSIS TO AIIS	.04453	.968
		CLIC TO UPPER ACETABULUM	.04453	.028
		CLIC TO ACETABULAR CENTRE	.04453	.884
	CLIC TO UPPER ACETABULUM	PSIS TO AIIS	.04453	.031
		BETWEEN PSIS AND PIIS TO AIIS	.04453	.028
		CLIC TO ACETABULAR CENTRE	.04453	.019
	CLIC TO ACETABULAR CENTRE	PSIS TO AIIS	.04453	.852
		BETWEEN PSIS AND PIIS TO AIIS	.04453	.884
		CLIC TO UPPER ACETABULUM	.04453	.019
WIDTH B	PSIS TO AIIS	BETWEEN PSIS AND PIIS TO AIIS	.03915	.679
		CLIC TO UPPER ACETABULUM	.03915	.725
		CLIC TO ACETABULAR CENTRE	.03915	.204
	BETWEEN PSIS AND PIIS TO AIIS	PSIS TO AIIS	.03915	.679
		CLIC TO UPPER ACETABULUM	.03915	.444
		CLIC TO ACETABULAR CENTRE	.03915	.391
	CLIC TO UPPER ACETABULUM	PSIS TO AIIS	.03915	.725
		BETWEEN PSIS AND PIIS TO AIIS	.03915	.444
		CLIC TO ACETABULAR CENTRE	.03915	.105
	CLIC TO ACETABULAR CENTRE	PSIS TO AIIS	.03915	.204
		BETWEEN PSIS AND PIIS TO AIIS	.03915	.391
		CLIC TO UPPER ACETABULUM	.03915	.105

Discussion

Our study to the best of our knowledge is the first study in Indian patients that measures the lengths of iliac screws trajectories. Due to morphometric differences among pelvis of western and Indian sub-continent, the study is of great clinical significance. Further, the other strength of the study is that we have defined two paths large and wide enough to insert widest iliac screws. This may be important in conditions where two screws are required for enhanced stability or in cases where due to surgical error, the primary path is breached and screw insertion is not possible.

The non-union and pseudoarthrosis rates have been found to be significantly higher when lumbo-sacral fixations are not augmented by iliac screw fixation [1-2]. McCord et al. compared 10 different lumbosacral fixation models and found that iliac screw model had largest capacity to bear high loads [7]. The insertion of these screws are difficult and have a steep learning curve. The accuracy of placement is of paramount importance due to close vicinity of various vital structures. Further, the literature does not support uniform entry site [1,2,11,12]. Liu et al. studied iliac screw paths in Chinese patients and found paths PSIS to AIIS and CLIC to upper edge of acetabulum to have similar lengths [1]. However, we found these lengths to be significantly different in our study. Further, Liu et al. found that PSIS to ASIS was thicker than other paths. Our study, however, showed no significant difference in width of these paths. Another important difference was the mean width in the Chinese and Indian pelvis of the iliac screw corridors. The mean width in their study for the PSIS to AIIS path was 17.3 mm; whereas the Indian pelvises had a narrower corridor of 13 mm. Above differences are probably due to differences in the pelvic morphology of the Chinese and Indian populations. This further highlights the importance of studies in various ethnic groups.

Similar to findings of Yilmaz et al. [2] who studied screw trajectories in American pelvises, we also found PSIS to AIIS to be longest screw pathway. However, they recommended path connecting a point between PSIS to PIIS to AIIS to be the second best path and recommended its usage when PSIS to AIIS trajectory could not be used. In contrast, we found CLIC to upper acetabulum to be longer compared to the above trajectory [12.5 vs 11.8 cm (p=.000)]. Also, another point of note is that the PSIS to AIIS corridor width was 16 mm in their study as compared to our study in which it was 13mm.

We believe that our study would help surgeons in their decision making to choose the optimal iliac screw trajectory. Regardless of the chosen trajectory, careful preoperative planning and intraoperative fluoroscopy is crucial for optimal screw placement.

Our study has few limitations. The study is of retrospective nature and is based on radiological assessment. Its true intraoperative correlation with respect to length and width of screw requires further study. Biomechanical and clinical studies could be performed to evaluate strength of various screw trajectories.

Conclusion

Iliac screw fixation is of paramount importance for lumbosacral stabilization. Of the studied paths, the trajectory from posterior-superior iliac spine to Antero-inferior iliac spine has the longest passage length and is the most optimal path for the Indian population. In case additional screws are required, trajectory from chaotic line - iliac crest intersection point (CLIC) point to Upper acetabulum provides the second largest screw passage.

Disclosures: There is no conflict of interest for all authors.

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