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A Prospective Cohort Study on the Morphometric Analysis of Anterior Column of the Acetabulum & Safety of Intramedullary Screw Fixation for its Fractures Using 3D-CT Pelvis

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Abstract: ***Background: There has been an upwards trend towards minimally invasive fixation of simple acetabular fractures. Compared to plate osteosynthesis which is a challenging task due to the anatomic complexity of acetabulum, lag screw fixation has been proven to attain anatomic reduction and interfragmentary compression with good clinic outcomes. Materials and Methods: CT scans of 95 uninjured adult pelvis were analysed. The axis of an anterior column was derived by joining the centres of its narrowest zones around the acetabulum proximally and the superior pubic ramus distally. Two types of screw trajectories along the axis of the anterior column were created based on the standard 4-mm and 6.5-mm screws. For the screw trajectories which passed safely through the narrow zone around the acetabular region safely, the trajectory lengths were limited to the point of first cortical perforation anywhere lateral the pubic tubercle. Results and Conclusion: In males, 4mm screws are applicable in 52 subjects out of 58 (89.66%) and 6.5mm screws are applicable in 36 out of 58 (62.07%) subjects. Similarly, in females, 4mm screws are applicable in 27 subjects out of 37 (72.97%) and 6.5mm screws are applicable in 12 out of 37 (32.43%) subjects. The p value of our data is 0.0005 which is significant. To conclude, the results provided in our study can form the basis of a larger prospective and anthropometry based study on the anterior column of the acetabulum.***

Keywords: acetabulum, anterior column, screw trajectory, narrowest zone

1. Introduction

Acetabulum fractures are pelvis fractures that involve the articular surface of the hip joint and may involve one or two columns, one or two walls, or the roof within the pelvis.

Anterior column fractures separate a segment of anterior acetabulum from the rest of the innominate bone. The fracture starts from the middle of the ischiopubic ramus below, and then passes through the anterior acetabulum. The incidence of isolated anterior column and anterior column fractures is about 6.3% of acetabular fractures[1].

There has been an upwards trend towards minimally invasive fixation of simple acetabular fractures. Compared to plate osteosynthesis which is a challenging task due to the anatomic complexity of acetabulum, lag screw fixation has been proven to attain anatomic reduction and interfragmentary compression with good clinic outcomes.[2,3] Biomechanical analysis shows that the fixation stiffness of lag screw fixation is comparable to plate fixation if placed correctly within the bone.[4]

A screw if not placed correctly can violate the margins of the anterior column thus injuring the articular surface and possibly the vital structures around it.[5] There have been a few studies in which the morphological variations of the anterior column and the narrow zones of its osseous corridor have been analysed. [6,7,8], However, only 2 CT based studies have precisely measured the morphometric variations and defined the direction of screws to be inserted into the anterior column.[9]

2. Materials & Method

Consecutive CT scans of 95 uninjured adult pelvis were analysed. The study was purely based on radiological data without the involvement of human subjects. These patients underwent CT studies for injuries and indications other than pelvic fractures.

Calculation of axis of anterior column

The axis of an anterior column was derived by joining the centres of its narrowest zones around the acetabulum proximally and the superior pubic ramus distally.

The vertical height (VH) was measured as the maximal distance from the articular surface to the superior surface of the anterior column while keeping it perpendicular to the tangential line on the joint surface or in a radially outward direction from the centre of the hip joint.

The mediolateral width (ML) was measured as the distance from the anterolateral apex to the medial extent of the

anterior column while bisecting the vertical height (VH).In the superior ramus region, the anteroposterior width (AP) width was measured in place of the mediolateral width (owing to its more frontal and anterior position). It was measured as the maximal anteroposterior extent of the bony corridor from the posterior surface and perpendicular to it.

The vertical height at the superior ramus region (VH2) was measured as the maximal distance from the caudal-most extent of superior ramus to its superior surface in a direction perpendicular to it. The centres of narrower dimensions for the acetabular region and superior ramus regions of the anterior column were joined to create its central axis. This was performed to ensure the passage of the screw trajectory through the centers of narrowest zones when kept in line with this calculated axis

Screw trajectories

Two types of screw trajectories along the axis of the anterior column were created based on the standard 4-mm and 6.5-mm screws. For the screw trajectories which passed safely through the narrow zone around the acetabular region safely, the trajectory lengths were limited to the point of first cortical perforation anywhere lateral the pubic tubercle**.**

3. Statistical Analysis

Means were calculated for quantifiable parameters and were compared among male and female groups using the unpaired t test. The difference was considered to be significant for p values < 0.05.

All experimental data (continuous variables) will be presented as the mean and standard deviation or median and range. Independent samples t-test will be used to compare the data between males and females. The threshold for statistical significance is to be set at p smaller than 0.05. SPSS (version 19.0, for Windows) were used to analyse the data.

The data will be compiled in MS Excel, Primer. The data will be presented in a table and graph wherever applicable. The data will be analysed as per objectives. Inferences will be drawn with the help of appropriate of significance.

4. Observation and Results

In our study, the subjects in age group 18-30 are 33 (maximum), 23 in age group 31-40, 24 in age group 41-50, 14 in age group 51-60 and 1 in age group >61 (minimum).

Table 1: Age wise distribution of subjects

Age (yrs)	No. of patients	Percentage
18-30	33	34.74
31-40	23	24.21
41-50	24	25.26
51-60	14	14.74
≥ 61	1	1.05
Total	95	100.00

Out of 95 subjects, males are 58 and females are 37. So the number of male subjects is significantly higher.

According to mode of injury, the subjects can be distributed as road traffic accidents (RTA), fall from height (FFH), fall from stairs and slip and fall. Most subjects presented following RTA which is 78 in number followed by FFH which is 9 in number.

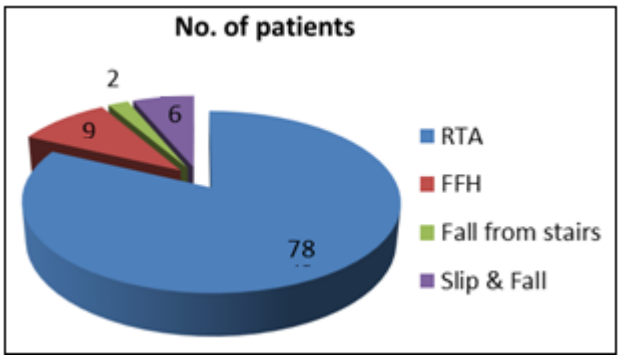

Figure 1: Distribution according to Mode of Injury

The analysis of morphometric variables show mean VH1 is 10.82mm with a range of 5.7-15.3mm; mean VH2 is 12.43mm with a range of 7-18.3mm; mean ML is 21.71mm with a range of 9.1-32.4mm; mean AP is 10.92mm with a range of 5.2-17.2mm; mean ACL is 111.37mm with a range of 80.6-132.1mm and mean screw size is 95.49mm with a range of 64.3-120.5mm. [VH1-Vertical Height 1 VH2-Vertical Height 2 ML-Medio Lateral length AP-Antero Posterior Length ACL-Anterior Column Length]

Table 2: Morphometric variables of the anterior column and screw size

Variable	Mean	SD	Range
VH1 (mm)	10.82	2.03	5.7-15.3
VH2 (mm)	12.43	2.41	7-18.3
ML (mm)	21.71	4.69	9.1-32.4
AP (mm)	10.92	2.33	5.2-17.2
ACL (mm)	111.37	10.83	80.6-132.1
Screw Size (mm)	95.49	15.98	64.3-120.5

The data shows that in males, 4mm screws are applicable in 52 subjects out of 58 (89.66%) and not applicable in 6 out of 58 subjects (10.34%).And 6.5mm screws are applicable in 36 out of 58 (62.07%) subjects and not applicable in 22 out of 58 (37.93%) subjects. The p value of our data is 0.0005 which is significant.

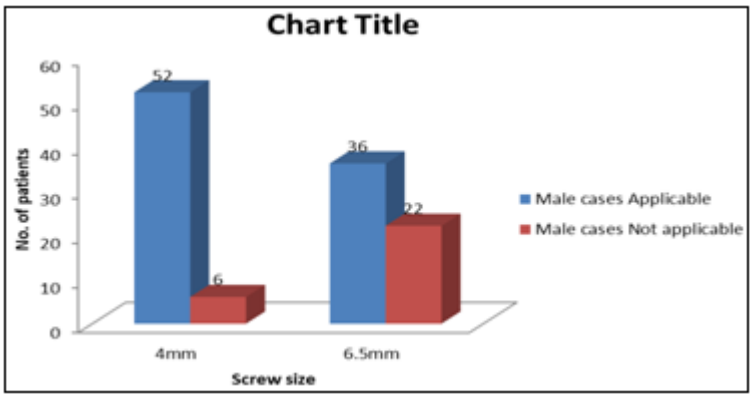

Figure 2: Applicability of 4mm and 6.5mm screws in males

The data shows that in females, 4mm screws are applicable in 27 subjects out of 37 (72.97%) and not applicable in 10 out of 37 subjects (27.03%). And 6.5mm screws are applicable in 12 out of 37 (32.43%) subjects and not applicable in 25 out of 37 (67.57%) subjects. The p value of our data is 0.0005 which is significant.

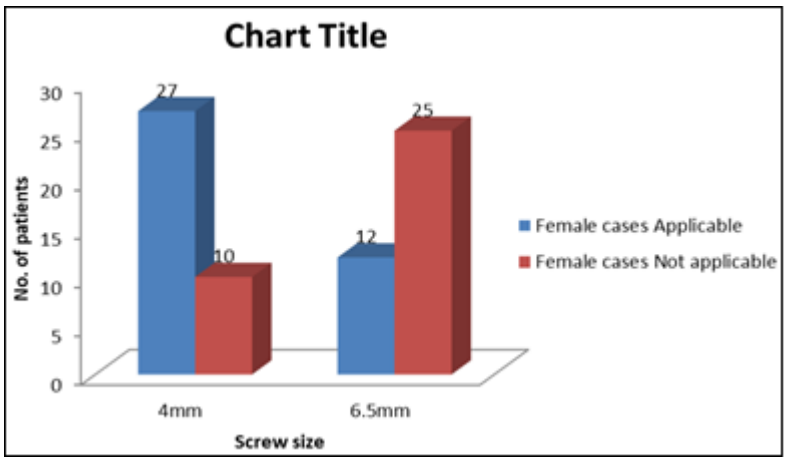

Figure 3: Applicability OF 4mm & 6.5mm screws in females

Our study shows mean screw size in males is 101.57mm and 85.94mm in females. The p value of this data is <0.0001 which is significant.

Table 3: Comparison of screw size between males and females

Gender	Screw Size		p value
	Mean	SD	
Male	101.57	15.5	<0.0001
Female	85.94	11.5	

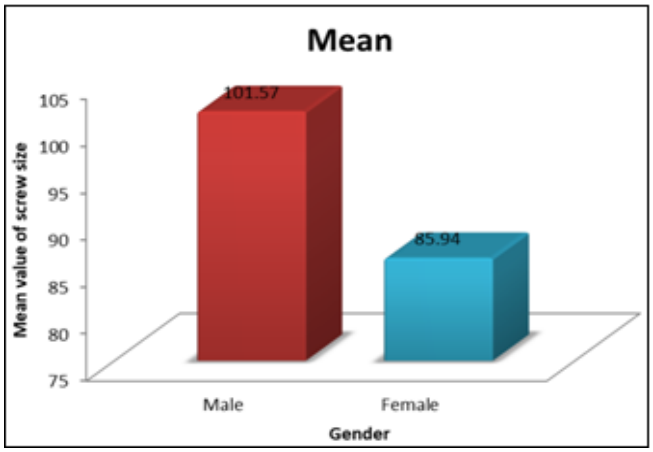

Figure 4: Chart showing mean value of screw size in males and females

5. Case Illustrations

Case 1:
A 55yr old male presented in Trauma emergency, SMS Hospital with injury on right forearm.
Mode of injury-RTA
Pelvis was uninjured

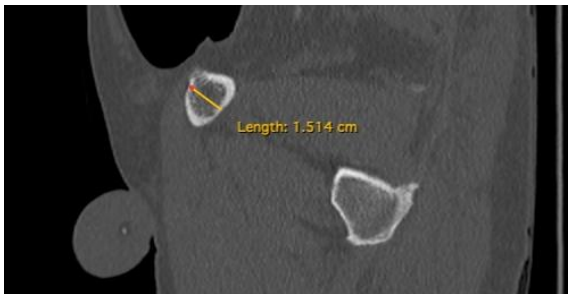

Figure 5 (a): Antero Posterior Length

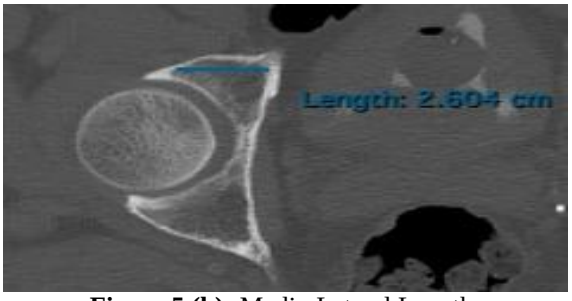

Figure 5 (b): Medio Lateral Length

Figure 5 (c): Vertical Height 1

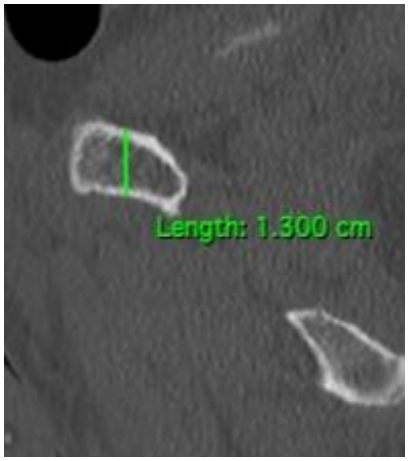

Figure 5 (d): Vertical Height 2

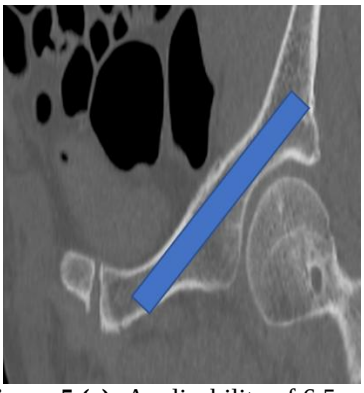

Figure 5 (e): Applicability of 6.5 mm

VH1-12.5mm
VH2-13.0mm
ML-26.04mm
AP-15.1mm

Anterior column length-106.5mm
Screw size-101.4mm
[VH1-Vertical Height 1 Vh2-vertical height 2 ML-MedioLateral Length AP-Anteroposterior length]

Case 2:
A 32yr old male presented in Trauma emergency, SMS Hospital with injury on right shoulder
Mode of injury-RTA
Pelvis was uninjured

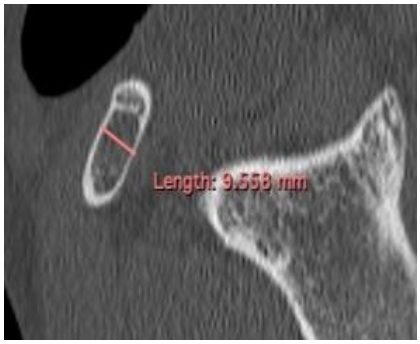

Figure 6 (a): AP Length

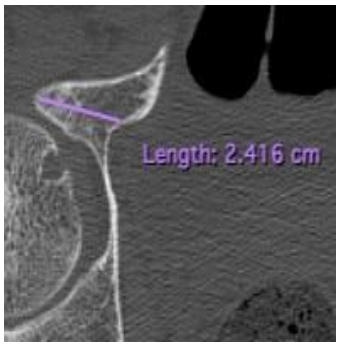

Figure 6 (b): Medio Lateral Length

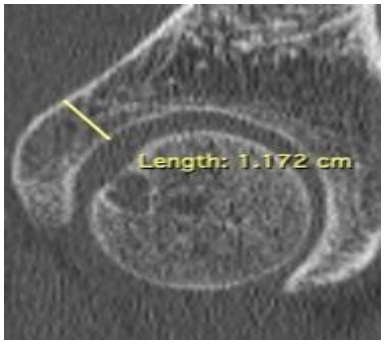

Figure 6 (c): Vertical Height 1

Figure 6 (d): Vertical Height 2

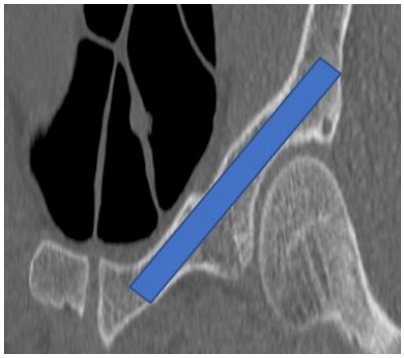

Figure 6 (e): APPLICABILITY OF 6.5mm SCREW

VH1-11.7mm
VH2-13.4mm
ML-24mm
AP-9.5mm
Anterior column length-106.9mm
Screw size-98.5mm
[VH1-Vertical Height 1 Vh2-vertical height 2 ML-MedioLateral Length AP-Anteroposterior length]

6. Discussion

In fractures of the anterior column of acetabulum that are simple and minimally displaced, intramedullary screw fixation is advantageous over plate fixation because of its less invasive nature and lesser soft-tissue insult[10,11].

Occasionally, in patients with complex acetabular fractures with extensive articular damage, preservation of the bone stock would be the only treatment option to prepare for a later arthroplasty. Intramedullary screw fixation can be helpful in such situations as it avoids extensive scarring related to wide exposure and soft tissue insult when plating techniques are used.
Our study tends to focus on the safety of the screw fixation of anterior column fractures in Indian patients.[12]

In our study, we observed that the mean mediolateral width at the proximal constriction zone (ML) was 21.71 mm with a range of 9.1-32.4mm, while its anteroposterior alternate in distal constriction zone (AP) was 10.92mm with a range of 5.2-17.2mm.

The mean vertical height of the proximal constriction zone (VH1) was 10.82 mm with range 5.7-15.3mm and that of the distal constriction zone (VH2) was 12.43mm with range 7-18.3mm.

When compared with the results in studies conducted by Shahulhameed A et al. in which the narrow dimension is 15.1mm, the narrower dimensions in both these regions are smaller in our study (Table 6).[13]

In our study, the vertical extent is always shorter than the mediolateral extent in the proximal (acetabular region) narrow zone compared with the distal (superior pubic ramus) narrow zone in all of the cases which is similar to the study conducted by Chen KN et al in which vertical extent was shorter than mediolateral extent in almost all the cases.

Thus, the vertical extent plays a critical role in the proximal constriction zone, and it can be considered as the chief parameter in deciding the usage of a particular diameter screw for intramedullary placement[7]

Our method of calculation of the axis of the anterior column by joining the centers of narrowest dimensions of proximal and distal narrow zones is comparable to the method used by Chen KN et al. which used virtual cylindrical implants were placed intra osseously both in left and right anterior column and simple compared with the methods used by Ochs BG et al. in which they examined the preformed bone stock of the anterior column in 260 hemipelvis (130 male and 130 female) and screws were virtually implanted using iPlan(®).[7,9]

In our study, the goal was to ensure the central placement of screw so as to avoid cortical perforation which is similar to the approach used by Feng et al. which used 3D reconstruction models and fluoroscopy to simulate the anterior column axial view image.[14]

In our study, in the female group, only 32.43% cases were able to safely contain 6.5-mm screw and 72.97% were able to safely contain 4mm screw while 62.07% of male cases were able to contain 6.5-mm screw safely and 89.66% were able to contain 4mm screw.

So the applicability of 6.5mm screws is higher than the applicability of 6.5mm screw in study conducted by Puchwein et al. which is 18% in females and 55% in males.[8]

Our study shows that 4mm screws are applicable in majority of the cases (72.97% in females and 89.66 in males) which is comparable to the study conducted by Routt et al. which states that 4.5mm can be used in place of 6.5mm screws and are contained better than 6.5mm screws.[15]

Our study states the entry of screw proximal to the narrow zone directed distally towards the pubic tubercle to allow better and safe containment of screw which is similar to the study conducted by Bozzio et al. which states that if one attempts to place a retrograde screw from the constriction on superior ramus, there are chances of injuring the obturator neurovascular bundle which runs closely on the inferior aspect.[16]

In our study, Vertical height at the acetabular region (VH1) is always smaller than the Vertical height at the superior ramus (VH2) which is similar to the results of study conducted by Peng et al. using 3DCT analysis which found distal zone of anterior column always wider than the proximal zone of anterior column.[17]

In a study conducted by Feng et al., the acetabular anterior column could safely accommodate not only one 7.3-mm screw, but also two 6.5-mm screws which differs majorly from our study in which 4mm screws and 6.5mm screws were found to be safely applicable in females and males respectively.[14]

7. Conclusion

Our study provides important information regarding morphometric variations of the anterior column of the acetabulum while addressing several issues related to screw fixation of anterior column fracture.

The vertical height of the acetabular constriction zone is the chief parameter in deciding the safe applicability of anterior column screw placement without perforation.

Males have a more spacious osseous corridor compared with females with 62.07% cases allowing safe screw placement compared with 32.43% cases in the female group when 6.5-mm-diameter screws are used.

To conclude, the results provided in our study can form the basis of a larger prospective and anthropometry based study on the anterior column of the acetabulum.

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