ORIGINAL STUDY

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Evaluatıon of the effect of pelvıs type ın percutaneous acetabular column fıxatıon: a computed tomography study

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This study aimed to evaluate the effect of pelvis type in percutaneous acetabular column fixation. What is the effect of pelvis type in percutaneous acetabular colon fixation? The available pelvic computed tomography (CT) scans which were obtained in the diagnostic imaging center with a 1 mm slice width were evaluated. The pelvic type was classified with the help of MPR (Multiplanar Reformat) and 3D (Three Dimensional) imaging modes. All evaluated bony pelvic structures were anatomically intact. 40 types of android, gynecoid, anthropoid, and platypelloid pelvis were determined. CT sections were created in MPR imaging mode. Anterior obturator oblique (AOO) and inlet images were created for anterior column evaluation, while iliac oblique (IO) and outlet images were created for posterior column evaluation. The possibility of obtaining a linear corridor for acetabular columns was investigated by measuring corridor width and lengthon images of pelvic CTs. A linear corridor could not be obtained between the pubic tubercle and the supraacetabular region of 12 (30%) CTs in the anterior column of gynecoid pelvis group. The diameter of the anterior column corridor was below 5.5 mm in 10 (25%) of Gynecoid pelvis group, 5 (12.5%) of Anthropoid pelvis group, and 10 of Platypelloid pelvis group, , and all those scans belonged to the female gender. There was a statistically significant difference between pelvis types in terms of anterior and posterior column diameters (p <0.001). While the android pelvis type had the highest diameter and corridor length in both anterior column and posterior column measurements, the gynecoid pelvic type had the lowest diameter and corridor length. In the evaluations made according to gender, both anterior and posterior column diameters were larger and longer in males than in females (p <0.001). Pelvis type is an important factor which can affect anterior and posterior column diameter and length of acetabulum. Pelvic typing before acetabular surgery can help the surgeon determining the most appropriate patient position, surgical approach, and implant selection.

Keywords: Pelvic fracture, Percutaneous screw fixation, 3d modeling, Pelvic type, Gynecoid, Android
Level of Evidence: Level 2..

INTRODUCTION

Technological developments and increased life expectancy have increased the incidence of pelvis-acetabulum fractures[15,21,27]. Additional injuries due to high-energy trauma or additional comorbidities in the elderly population make the management of these fractures difficult. Judet and Letournel[13] published their work on the surgical treatment of acetabular fractures over half a century and it is widely accepted that displaced acetabular fractures should be treated with the same principles as other intra-articular fractures by enabling early patient rehabilitation with anatomical reduction and stable internal fixation[5,19,20]. During the intervening time, significant changes have occurred specific to the management of acetabular fractures[26]. In this context, various surgical approaches have been developed, extended, and likewise minimized or completely abandoned[12,26,34]. A quarter of a century ago, Rout et al.[29] defined percutaneous fixation for the posterior ring and brought a revolutionary approach in management of those fractures. Until then, large posterior approaches were being used routinely for the posterior ring fractures but today percutaneous fixation of the posterior ring is accepted as the standard treatment in many institutions treating pelvic fractures.

While the mainstay of surgical fixation for acetabular fractures remains standard plate and screw fixation, the use of percutaneous fixation has been initiated and the frequency of its use is increasing day by day with new technologies such as computer navigation and 3D printing. Treatment of pelvic and acetabular fractures with minimally invasive reduction techniques and percutaneous fixation is now widely accepted[2]. However, there are controversies regarding the safety and accuracy of inserting percutaneous screws, and the size, insertion point, and direction of the screw are still under debate[1,22,28]. It is known that acetabular columns must have a sufficiently wide and straight corridor for percutaneous screw fixation. This study aimed to evaluate the effect of pelvis types on the structural properties of acetabular columns for percutaneous screw applications.

MATERIALS AND METHODS

After obtaining the approval of the Local Ethics Committee, 1 mm cross-sectional pelvic CTs of patients aged 18-100 years were examined in the diagnostic imaging center of our hospital. Images with impaired pelvic anatomy such as recent or previous pelvis-acetabular fracture, primary and / or metastatic tumoral formation in the pelvis, developmental hip dysplasia and previous surgical intervention related to pelviswere excluded from the study. In addition, diseases that may affect pelvis rotation such as limb length discrepancy, kyphosis and scoliosis were excluded. CT images were evaluated using MPR and 3D imaging mode of the imaging system (Sectra Workstation IDS7 Version 21.2.13.6313 ©2019 Sectra AB, Linköping, SWEDEN). A researcher analyzed pelvis CT images using the measurement techniques described in the literature[6,16,30]. The anterior pelvic entry pattern, the largest transverse diameter and anteroposterior diameter in the inlet section view, the interspinous-intertuberous distance and the subpubic arch in the pelvic outlet section view and the sacrosciatic notch, sacral inclination in the pelvis lateral section view were examined (Figure 1). Pelvis CTs were evaluated until each group reached 40, and a total of 160 pelvis imaging was performed. All of the 160 pelvis imaging were classified into four types according to main pelvis types (Figure 2). On the other hand, anterior obdurator oblique (AOO) and inlet images for anterior column evaluation, iliac oblique (IO) and outlet images for posterior column evaluation were created by 3 other researchers, who did not have information about pelvis types. In these sections, it was evaluated whether a linear intramedullary osseous fixation corridor described[2,32] for fixing the columns could be obtained (Figure 3). In the CT images obtained from the linear corridor, the widths and lengths of the columns in both

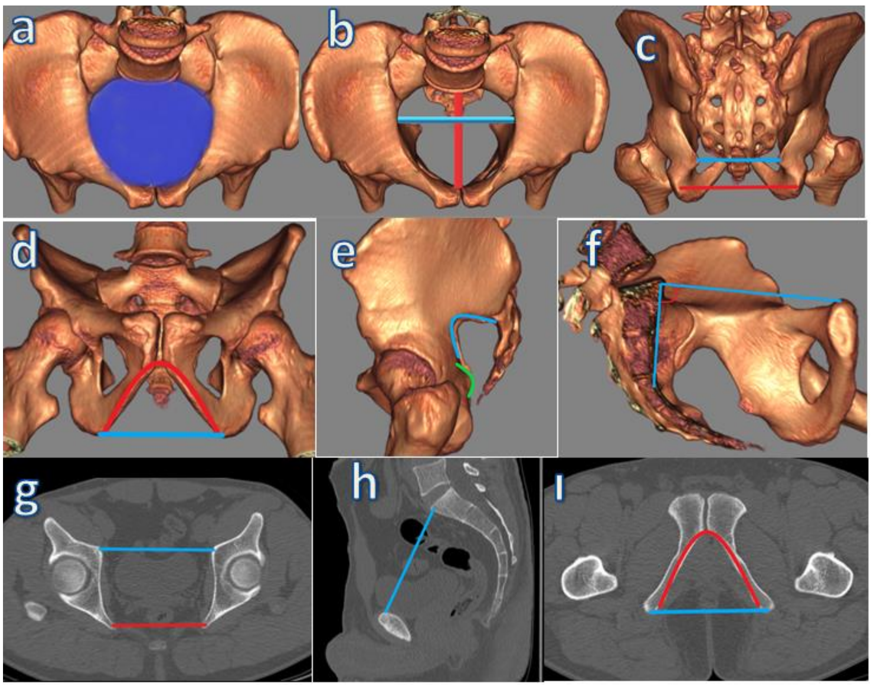

Figure 1. — Pelvis typing; a) The anterior pelvic entry pattern, b) Anteroposterior diameter of inlet(red), widest transverse diameter of inlet(blue), c) İnterspinous distance(blue), intertuberous distance(red), d) Subpubic arch(red) and transverse diameter of outlet(blue) e) Sacrosciatic notch(blue), ischial spine (green), f) Sacral inclinasyon, g) Widest transverse diameter(blue), intertuberous distance(red), ı) Subpubic arch(red) and transverse diameter of outlet(blue).

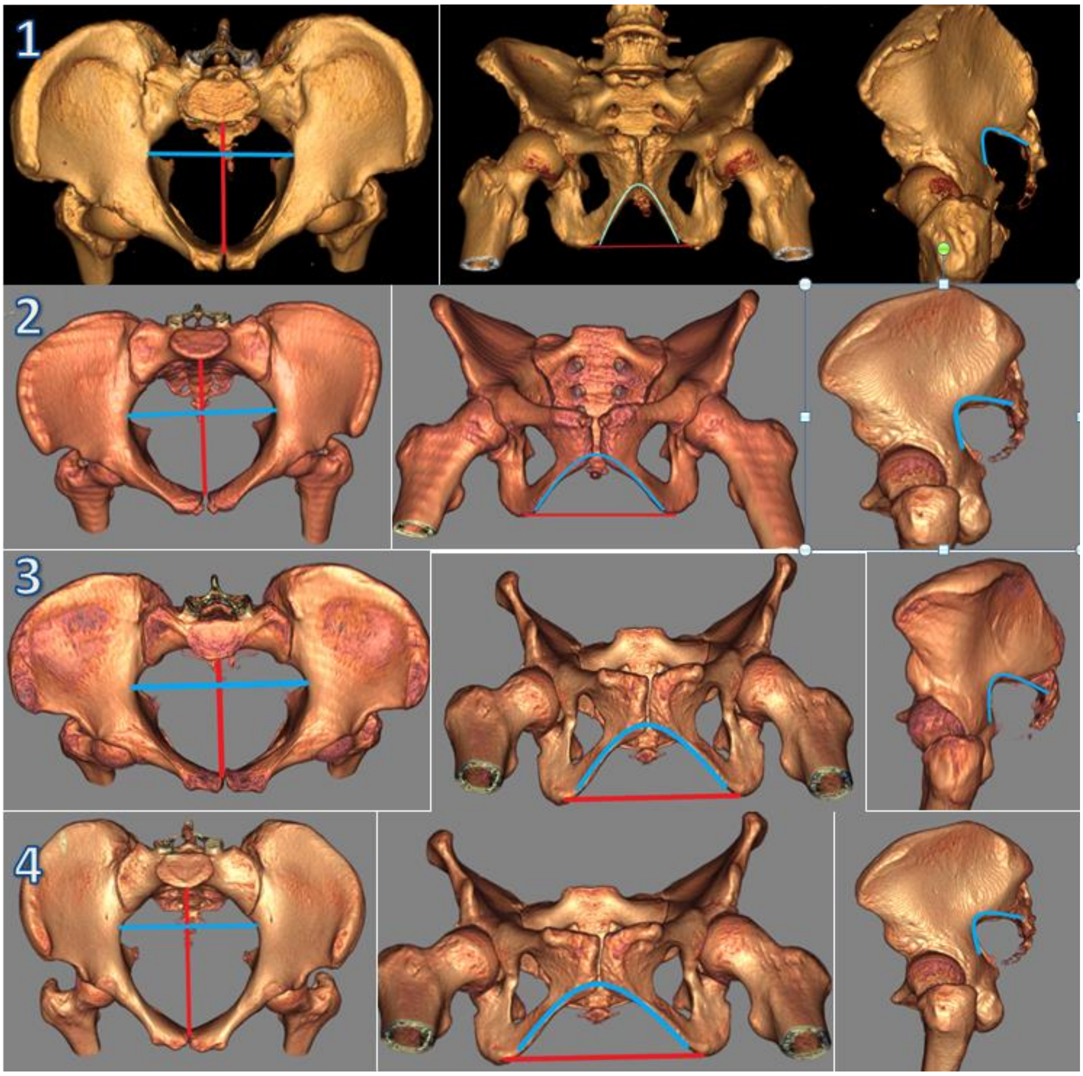

Figure 2. — Pelvis Types: 1) android type, 2) gynecoid type, 3)platypelloid type, 4) anthropoid type.

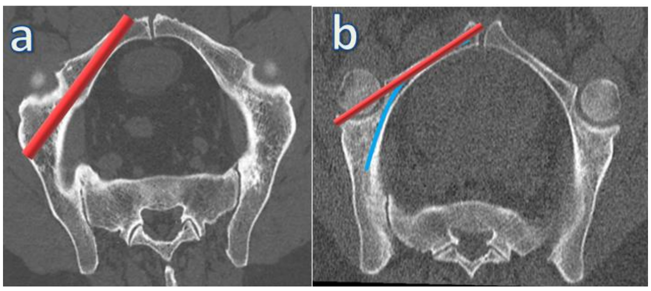

Figure 3. — a) Linear corridor achievable CT scan for anterior column, b) CT examination where linear corridor cannot be obtained due to increased concavity of the anterior column.

planes were measured (Figure 4). The cross-sectional images with the shortest width and length values were used to create corridors. Final corridor diameter and length values were calculated by taking the average of values determined by 3 researchers for each corridor. The suitability of acetabular columns for percutaneous screw fixation and corridor diameter and length measurements were compared according to pelvis types.

Data were analyzed with IBM SPSS V23. Conformity to normal distribution was evaluated with the Kolmogorov-Smirnov test. The Chi-square test was used to compare the groups according to gender. An Independent two-sample t-test was used to compare normally distributed data according to gender. One-way analysis of variance was used to compare normally distributed data according to the groups, and multiple comparisons were performed with Tamhane's T2 test. Analysis results were presented as mean ± standard deviation and median (minimum-maximum) as frequency (percentage) for quantitative data. The significance level was presented as $p<0.05$.

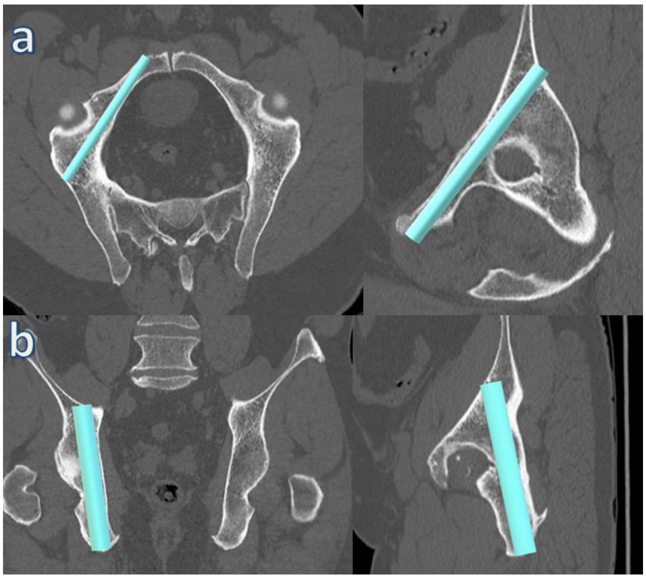

Figure 4. — a) The appearance of the anterior column in the inlet cross-section and anterior obdurator oblique cross-sectional image in CT examinations obtained from the linear corridor, b) The appearance of the posterior column in the outlet section image and the iliac oblique section image in CT examinations obtained from the linear corridor

RESULTS

160 pelvic CT scans (102 Female, 58 Male) with android (40), gynecoid (40), platypelloid (40), and anthropoid (40) features were examined. The mean age of the study sample was 51.3 ± 21.6 (min:18, max:100). The average age was 53.3 ± 21.9 in males and 50.2 ± 21.5 in females. While no statistical difference could be detected in the mean age of the patients according to gender, the patients in the anthropoid pelvis group were younger compared to other groups (p<0.005) (Table I). When the gender distributions were examined, 40% of the patients in the android pelvis group, 100% in the gynecoid pelvis group, 55% in the anthropoid pelvis group, and 60% in the platypelloid pelvis group consisted of female patients (Table I).

When the diameter measurements made for the anterior column were evaluated, a linear corridor could not be obtained between the pubic tubercle and the supracetabular region of 12 (30%) CT scans in the gynecoid pelvis group. In other pelvis types, a linear corridor could be formed. In addition, the corridor diameter was below 5.5 mm in 10 (25%) CT examinations of the Gynecoid pelvis group, 5 (12.5%) of the Anthropoid pelvis group, and 10 (25%) of the Platypelloid pelvis group. Anterior column diameter was over 6.5 mm in all Android pelvis types. The android pelvis type had the largest diameter, while the gynecoid pelvis type had the narrowest diameter. Android pelvis type had significantly higher anterior column diameter compared to other pelvis types (p <0.001) (Table II). Anterior column diameter was significantly lower in females with 6.1±1.2mm compared to males who had an average diameter of 9.3±1.3mm (p<0.001) (Table III). In addition, all CT examinations that a linear corridor for the anterior column could not be obtained or whose corridor diameter was less than 5.5 mm belonged to the female gender. In other words, a linear corridor for the anterior column can be obtained in all males. When the anterior column length measurements were evaluated, there was no statistically significant difference between pelvis types, while there was a statistically longer anterior column in males compared to females (p <0.001).

When the posterior column of the acetabulum was evaluated, a linear corridor could be obtained in all pelvis types. While the android pelvis type had the widest posterior corridor diameter, the group with the narrowest corridor diameter was the gynecoid pelvis type. While the mean corridor diameter was 16.3±2.5mm in the android pelvis type, it was 14.2±1.3mm in the gynecoid pelvis type. There was a statistically significant difference between pelvis types in terms of posterior column diameter (p <0.001) (Table II). When posterior column length measurements were evaluated,

Table 1. — Comparison of gender distribution and mean age by groups.

	Android Pelvis Group	Gynecoid Pelvis Group	Andropoid Pelvis Group	Platypelloid Pelvis Group	Test statistics	p
Gender						
Female	16 (40)[a]	40 (100)[b]	22 (55)[a]	24 (60)[a]	=34,077	**<0,001**
Male	24 (60)	0 (0)	18 (45)	16 (40)		
Age Mean ±sd	61,1 ± 22,5[b]	50,6 ± 20,4[b]	34,6 ± 20,4[a]	59,1 ± 10,8[b]	F=16,396	**<0,001**
	Female 50,2 ± 21,5 (min:18,0–max:100,0)		Male 53,3 ± 21,9 (min:16,0 –max: 83,0)		t=-0,883	0,379

Ki-kare test statics, F: One-way analysis of variance test statistics, t: Independent two-sample t-test statistic, sd: standard deviation. [a-b]: There is no difference between groups with the same letter.

Table II. — Comparison of quantitative parameters by groups.

		Android Pelvis Group	Gynecoid Pelvis Group	Andropoid Pelvis Group	Platypelloid Pelvis Group	Test statistics	p
Acetabulum anterior column diameter(mm)	Mean ±sd	9,0 ± 1,6[c]	6,0 ± 1,3[a]	7,5 ± 1,9[b]	6,4 ± 1,5[a]	F=31,663	**<0,001**
	Mean(min-max)	9,1 (6,5 - 11,9)	6,5 (3,8 - 8,2)	6,5 (5,3 - 10,1)	6,3 (4,0 - 8,5)		
Acetabulum anterior column length(mm)	Mean ±sd	119,2 ± 8,5	114,9 ± 8,1	120,3 ± 11,3	119,6 ± 8,9	F=2,391	0,075
	Mean(min-max)	120,0 (101,0 - 137,0)	115,0 (100,0 - 130,0)	126,0 (100,0 - 132,0)	119,0 (101,0 - 133,0)		
Acetabulum posterior column diameter(mm)	Mean ±sd	16,3 ± 2,5[b]	14,2 ± 1,3[a]	15,8 ± 2,9[b]	15,1 ± 1,4[b]	F=9,294	**<0,001**
	Mean(min-max)	15,9 (10,8 - 21,3)	13,9 (11,4 - 16,6)	15,1 (12,3 - 21,6)	15,3 (13,5 - 18,0)		
Acetabulum posterior column length(mm)	Mean ±sd	133,5 ± 11,5[a]	124,8 ± 7,8[b]	128,1 ± 8,0[ab]	129,3 ± 8,7[ab]	F=5,384	**0,002**
	Mean(min-max)	131,2 (113,0 - 155,0)	125,5 (110,0 - 139,5)	130,0 (116,4 - 141,9)	126,4 (115,0 - 142,5)		

F: One-way analysis of variance test statistics, [a-c]: There is no difference between groups with the same letter, mm: millimeter, sd: standard deviation.

Table III. — Comparison of quantitative parameters by gender.

	Female		Male		Test statistics	p
	Mean ± sd	Mean (min. - max.)	Mean ± sd	Mean (min. - max.)		
Acetabulum anterior column diameter(mm)	6,1 ± 1,2	6,1 (3,8 - 9,0)	9,3 ± 1,3	9,4 (7,2 - 11,9)	t=-15,458	**<0,001**
Acetabulum anterior column length(mm)	116,3 ± 9,3	116,0 (100,0 - 133,0)	122,7 ± 8,5	124,6 (107,0 - 137,0)	t=-4,203	**<0,001**
Acetabulum posterior column diameter(mm)	14,6 ± 1,5	14,6 (10,8 - 18,0)	16,8 ± 2,6	17,2 (11,5 - 21,6)	t=-5,978	**<0,001**
Acetabulum posterior column length(mm)	124,9 ± 7,0	125,4 (110,0 - 139,5)	136,0 ± 9,4	136,5 (117,0 - 155,0)	t=-7,839	**<0,001**

t: Independent two-sample t-test statistic, sd: standard deviation.

it was parallel to the corridor diameter measurements. The longest corridor was in the android pelvis group, the shortest corridor length belonged to the gynecoid pelvis group. There was a statistically significant difference according to pelvis types (p=0.002) (Table II). When posterior column diameter and length measurements were evaluated according to gender, posterior column diameter and length measurements were significantly higher in males than in females (p<0.001) (Table III).

DISCUSSION

Although open reduction and internal fixation is still the gold standard treatment for displaced acetabular fractures, the range of indications for percutaneous surgery is expanding day by day, thanks to surgical advances and advances in imaging techniques. The percutaneous approach is associated with fewer complications than open techniques[18]. However, the complex regional anatomy makes percutaneous screw placement a difficult procedure. Percutaneous screw placement is a technically demanding procedure that requires the surgeon to fully understand the pelvic osseous fixation pathways and their fluoroscopic imaging[3].

Clinical, anatomical, and radiological studies have been conducted to understand regional anatomy. In these studies, osseous fixation ways, column diameters and lengths, and the effect of gender differences on these parameters were investigated. In the studies conducted for the acetabulum anterior column and superior pubic ramus, studies are stating that a linear corridor was detected in all patients[1,9,11,25], as well as there are studies in the opposite direction indicating that screw insertion failure, screw separation, loss of reduction and pull out of screws in female gender[29,32]. In addition, anatomical[9] and radiological1[7,10,24,33], studies have shown that women do not always have a long, thick screw corridor for fixation of the acetabulum anterior column. Although the studies examining the differences between male and female genders regarding the anterior column of the acetabulum are evident in the literature, we could not find a study about the effect of pelvis type on obtaining a corridor for screw placement[7,10]. In our study, the effect of the pelvis type on the osseous fixation paths in the acetabulum anterior and posterior columns was analyzed. In 55% of the gynecoid pelvis types, either a linear corridor for the anterior column could not be created or the diameter of the corridor was less than 5.5 mm. In other words, according to this study, only 45% of the gynecoid pelvis type were suitable for percutaneous screw fixation for the anterior acetabular column. In the radiological studies conducted by Chen et al.[7] to measure the anterior column, it was stated that in 17.6% of female patients, the corridor diameter was less than 5 mm, and in 40.5% it was between 5 and 6.5 mm. In addition, it has been stated that the angulation between the acetabular fossa and the anterior column regions at the obturator foramen level is significantly higher in women than in men. This means that the anterior acetabular column has a more concave structure in women. In radiological studies evaluating the diameters of the anterior column of the acetabulum according to gender differences, it has been determined that the diameter of the corridor is wider in men than in women[7,10,33]. Female gender has a disadvantage compared to male gender in terms of corridor diameter width for acetabular anterior column percutaneous screw fixation. One of the most important findings of our study is that the inability to obtain a linear corridor in the anterior acetabular column in some females may be due to the dominance of gynecoid pelvis feature in the female gender.

In clinical and cadaveric studies conducted for the fixation of acetabulum posterior column, it has been stated that screws from 6.5 mm to 8 mm are used safely[4,8,14,17,23,31,32,35,36]. In radiological studies, the posterior column diameter varied from 11.4mm to 20.7mm on average, and the length of the posterior column from 96.4mm to 139.5mm[1,24,36]. In cadaver studies, the mean posterior column diameter was 21.3mm[31] and posterior column length ranged from 104.8mm[23] to 154mm[31] on average. In these studies, it was stated that posterior column diameter and length values were higher in men than in women[1,24,31]. Our study data also had a narrower and shorter posterior column in the female gender, in accordance with the literature. When the effect of pelvis type on the posterior column was evaluated, other pelvis types except Gynecoid pelvis type had no significant effect on posterior column diameter. Gynecoid pelvis type was the pelvis type with the narrowest corridor diameter in the posterior column as in the anterior column. Although the posterior column diameter values differ in a wide range among the studies in the literature, all pelvis types present a posterior corridor that is wider and longer than the screw diameter used in clinical studies. We think that the differences between the studies are due to the gender, age, height, weight, racial, and pelvis type differences of the study samples.

CONCLUSIONS

Although the indications for percutaneous acetabular surgery is expanding day by day, a linear corridor may not be easily obtained for the anterior column, especially in patients with gynecoid pelvic anatomical structure. In addition, it is important to know that 25% of pelvic structures other than the android pelvis type may have an anterior acetabular corridor diameter below 5.5 mm.

Gynecoid pelvis group has a narrower and shorter linear corridor in the posterior acetabular column compared to other pelvis groups. Existing implants provide a tablet-dot treatment opportunity in percutaneous acetabular fixation and may not provide an appropriate treatment opportunity in all pelvic structures. In this context, our study may shed light on offering an à la carte treatment specific to the pelvis type or even each pelvic structure.

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