Özgün Araştırma / Original Article

Turk J Hip Surg 2022;2(1):138-144
https://doi.org/10.5505/TJHS.2022.03522

Türkiye Kalça Cerrahisi Dergisi
Turk J Hip Surg

Effect of Lumbar Variables on Acetabular Version: Analysis with Pelvic-CT Scan

Lomber değişkenlerin asetabular versiyona etkisi: Pelvik-BT ile analiz

Yüksel Uğur Yaradılmış, Alparslan Kılıç, Ali Teoman Evren, Mehmet Ali Tokgöz, Hakan Şeşen, Murat Altay

Sağlık Bilimleri Üniversitesi, Keçiören Eğitim ve Araştırma Hastanesi, Ortopedi ve Travmatoloji Ana Bilim Dalı, Ankara

Geliş / Received: 30.09.2021 **Kabul / Accepted:** 07.05.2022 **Online Yayın / Published Online:** 25.05.2022
Cite as: Yaradılmış U. Y., Kılıç A., Evren T. A., Tokgöz A. M., Şeşen H., Altay M. Effect of Lumbar Variables On Acetabular Version: Analysis with Pelvic-CT Scan Turk J Hip Surg 2022;2(1):138-144

ABSTRACT

Objective: *The acetabular version is important both for the diagnosis of hip pathologies and in hip replacement surgery. This study aimed to present the acetabular version of the Turkish population and to determine the variation of the acetabular version according to pelvic and lumbar parameters.*

Methods: *A total of 300 patients with pelvic and spinal CT scans aged 20-80 years without lumbar, pelvic, and hip pathology or fractures were included. Bilateral acetabular version, anterior acetabular sector angle (AASA), and posterior acetabular sector angle (PASA) were measured on axial pelvic CT scans. The pelvic tilt, sacral slope, pelvic incidence, and lumbar lordosis were measured in spinal CT sagittal sections. Sagittal spinal alignment was typed according to Roussouly classification. The variation of the acetabular version according to demographic, pelvic, and lumbar parameters was determined.*

Results: *Acetabular measurements; mean acetabular version: 18.8±5.9, AASA: 65±8.9, PASA: 99.4±9.9. While there was no statistically significant difference in acetabular version measurements according to age and gender (p=0.766, p=0.087), anteversion was the same on both sides: 18.8±5 on the right and 18.8±6.7 on the left (p=0.841). Mean pelvic tilt was 10.9±5.3, mean sacral slope was 41.1±7.5, mean pelvic incidence was 52±9.5 and all three measurements were significantly correlated with anteversion (respectively: p<0.001, p=0.017, p<0.001). Mean lumbar lordosis was 31.7±11.3 and it was significantly correlated with anteversion (p=0.001). An increase in anteversion was statistically significant according to the Roussouly classification (p=0.05).*

Conclusion: *The acetabular version is in a wide range, similar to that of the contralateral hip. Lumbar and pelvic parameters have positive correlations with acetabular anteversion.*

Keywords: *Acetabular version, lumbar lordosis, pelvic tilt, sacral slope, Roussouly classification*

ÖZET

Amaç: *Asetabular versiyon, hem kalça patolojilerinin tanısında hem de kalça protez cerrahisinde doğru komponent oryantasyonu için önemlidir. Çalışmamızda hem Türk toplumunun asetabular versiyonunun sunulması hem de pelvik ve lomber değişkenler karşısında asetabular versiyonun değişiminin belirlenmesi amaçlanmıştır.*

Gereç ve Yöntem: *Hastanemizde Ocak 2020-Ocak 2021 tarihleri arasında travma nedeniyle çekilen pelvik ve spinal BT'ler incelendi. Lomber, pelvik ve kalça patolojisi olmayan 20-80 yaş aralığındaki 300 hasta çalışmaya dahil edildi. Hastaların aksiyel pelvis BT kesitleri üzerinden bilateral asetabular versiyonu, anterior asetabular kısım açısı (AASA) ve posterior asetabular kısım açısı (PASA) ölçüldü. Hastaların spinal BT sagital kesitlerinden; pelvis tilt, sakral slop ve pelvik insidans ölçüldü. Omurga değerlendirmesi için Roussouly sınıflandırmasına göre tiplendirme yapıldı ve lomber lordoz ölçüldü. Asetabular versiyonun demografik verilere, pelvik ve lomber değişkenlere göre değişimi belirlendi.*

Bulgular: *Asetabular ölçümler; ortalama asetabular versiyon: 18.8±5.9, AASA: 65±8.9, PASA: 99.4±9.9 olarak bulundu. Asetabular versiyon ölçümlerinde; yaş ve cinsiyet değişkenine göre istatistiksel olarak fark gözlenmezken (p=0.766, p=0.087), taraf ölçümlerinde sağ: 18.8±5, sol: 18.8±6.7 anteversiyon olmak üzere aynı bulundu (p=0.841). Hastaların lomber lordozu 31.7±11.3 olup anteversiyon ile korelasyonu anlamlı bulundu (p=0.001). Pelvik tilt: 10.9±5.3, sakral slop: 41.1± 7.5 ve pelvik insidans: 52±9.5 olup anteversion ile korelasyonu anlamlı bulundu (sırasıyla: p<0.001, p=0.017, p<0.001). Roussouly sınıflandırmasına göre tip arttıkça anteversiyonda artış gözlendi ve bu artış da istatistiksel olarak anlamlı idi (Tip 1: 14.9±5.1, Tip2: 18.3±5, Tip 3: 18.7±4.7, Tip4: 20.1±5.2, p=0.05).*

Sonuç: *Asetabular anteversiyon değeri beklenenden daha geniş bir aralıkta olup karşı kalça ile benzerdir. Lomber ve pelvik değişkenler asetabular anteversiyona doğrudan etkili olup pozitif korelasyon göstermektedir.*

Anahtar Kelimeler: *Asetabular anteversiyon, lomber lordoz, pelvik tilt, pelvik insidans, sakral slop, Roussouly sınıflandırması.*

Sorumlu Yazar / Corresponding Author:
Dr. Yüksel Uğur Yaradılmış ugur_yaradilmis@outlook.com

Yaradılmış U. Y. 0000-0002-7606-5690
Kılıç A. 0000-0002-3721-7006
Evren T. A. 0000-0002-1741-3894
Tokgöz A. M. 0000-0002-4056-3743
Şeşen H. 0000-0001-6874-7061
Altay M. 0000-0002-1898-3733

INTRODUCTION

The acetabular version is important both in the diagnosis of hip pathologies and hip surgery. The abnormal acetabular version has been associated with a variety of pathological hip conditions such as labral tears, femoroacetabular impingement (FAI), and hip osteoarthritis.[1–4] Recognition and appropriate treatment of abnormal acetabular version are crucial to prevent irreversible hip damage. Acetabular orientation is of great importance in hip reconstruction surgery. Knowledge of the spatial orientation of the native acetabulum can prevent malposition of the acetabular component, which can lead to increased wear and instability in the case of total hip arthroplasty (THA).[5, 6]

The anatomical orientation of the acetabulum in the horizontal plane is called version, which is around 20 degrees anteversion.[7, 8] Acetabular anteversion is affected by many variables such as ethnic and epidemiological characteristics. The most well-known examples are the positive correlation of acetabular version with increasing age and higher values in women.[9]

The hip is in a dynamic and complex interaction with both the spine and the pelvis. Spinopelvic mobility is questioned more in the current literature and both lumbar, pelvic, and hip parameters change with the position of the patient. Adaptation processes are performed from standing to sitting; the sacrum moves posteriorly, lumbar lordosis decreases, and acetabular anteversion increases.[10] The position of the pelvis in the static position also affects the acetabular version, as does whether it is in antevert, neutral, or retrovert position. When the pelvis is retroverted (increased posterior pelvic tilt), the acetabular version increases.[11] Lumbar typing was defined by Roussouly and is used for lumbar evaluation.[12] The effect of lumbar typing on the hip version is not clear. The supine position is frequently used both for diagnostic magnetic resonance imaging (MRI) position and for lateral surgical approach in hip arthroplasty. The effect of patients' lumbar and pelvic parameters on the acetabular version will add innovation to the literature for measurements in CT in the supine position.

This study aimed to present the acetabular version of the Turkish population with the epidemiological variables and to determine the change of acetabular anteversion versus lumbar variables.

MATERIAL – METHOD

This retrospective, observational study was conducted in Kecioren Health Practice and Research Hospital, and ethical approval was obtained from the same hospital. We evaluated pelvic and spinal CT scans performed in our hospital between January 2020 and January 2021. A total of 300 patients aged 20-80 years without lumbar, pelvic, and hip pathology or fractures were included. Patients who have a hip fracture (n=4), vertebral fracture (n=4), and pelvic fracture (n=2) were excluded from the study. Bilateral acetabular version, anterior acetabular sector angle (AASA), and posterior acetabular sector angle (PASA)

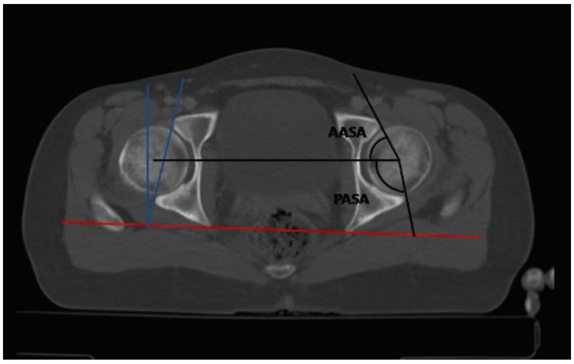

Figure 1. Acetabular measurements; right acetabulum: angle between blue lines is acetabular version (red line: horizontal line joining the posterior margins of both acetabula), left acetabulum: ASA and PASA measurements

were measured on axial pelvis CT scans **(Figure 1).** CT acetabular version measurement technique; axial cut extending through the center of a best-fit circle on the central coronal reconstructed cut (inset image) was used to calculate the equatorial acetabular version. The acetabular version angle between a line drawn tangential to the anterior and posterior walls of the acetabulum and a horizontal line joining the posterior margins of both acetabuli.[13] The angle from the perpendicular axis was obtained by subtracting this angle from 90°. The AASA and PASA were measured in the equatorial plane in the axial plane sections, just as Anda et al. had performed.[14] The AASA measurement is the measurement of the angle between a line connecting the anterior acetabular margin, the center of the femoral head, and intercapital centerline; and PASA ise the measurement of the angle between a line connecting posterior acetabular margin, the center of the femoral head, and the intercapital centerline.

Pelvis tilt, sacral slope, and pelvic incidence were measured on spinal CT sagittal sections.[15] Spine typing was done according to Roussouly classification and lumbar lordosis was measured.[12, 14] The change of acetabular version according to demographic data, pelvic and lumbar parameters was determined.

All measurements were performed on CT scans by three different surgeons. Each surgeon measured the radiographs in sequence three times.

Statistical analysis

Data obtained in the study were analyzed statistically using SPSS v.22 software, and at a confidence interval of 95%. Qualitative data were stated as frequency distribution and quantitative data were stated as mean, minimum, and maximum values. Inter-observer and intra-observer reliability analysis of the continuous variables was performed with the intraclass correlation coefficient and 95% confidence interval. Interpretation of the data was performed, according to Koo and Li. [15] Kappa statistics were used to establish a relative level of agreement on the categorical variables. Interpretation of the data was performed according to Landis and Koch.[16] Agreement was graded as slight (κ = 0–0.2), fair (κ = 0.21–0.40), moderate (κ = 0.41–0.60), substantial (κ = 0.61–0.80), and almost perfect (κ = 0.81–1). Compliance of the variables included in the analysis with normal distribution was analyzed with the Kolmogorov–Smirnov test. Mann-Whitney and ANOVA tests were respectively used for comparison between acetabular parameters and demographic variables. Pearson correlation test (r values) was used for correlation between parameters. Correlation between acetabular parameters with lumbar and pelvic measurements was evaluated with the Mann–Whitney U test. As the acetabular parameters in the Roussouly classification were applied with the Mann Whitney and Kruskal Wallis tests. The statistical significance value was accepted as p<0.05.

RESULTS

The mean age of the patients was 43±17.8 (20-86), 82 female and 218 male (F/M:1/2.5). Demographic parameters and radiographic measurements (the mean of Observer A, Observer B, and Observer C) are presented in **Table 1.** The measurements of the observers and the inter-observer reliability were given in **Table 2.** The results of the measurements were as follows; mean acetabular version was 18.8±5.9 (range: 6-34), AASA: 65±8.9 (range: 39-91), PASA: 99.4±9.9 (range: 75-119) **(Figure 2).** While there was no statistical difference in acetabular version measurements according to age and gender (p=0.766, p=0.087), it was the same anteversion value for the side as 18.8±5 for the right and 18.8±6.7 for the left (p=0.841). Acetabular measurements values according to gender, age, or side groups are presented in **Table 3.**

Table 1: Demographic and radiological measurements

	Patient
Age	43±17.8 (20-86)
Gender (Female/Male)	82/218
Acetabular anteversion	18.8±5.9 (6-34)
AASA	65±8.9 (39-91)
PASA	99.4±9.9 (75-119)
Lumbar lordosis	31.7±11.3 (2-72)
Sacral slop	41.1± 7.5(20-60)
Pelvic tilt	10.9±5.3 (2-33)
Pelvic incidence	52±9.5 (26-87)
Roussouly classification	
Type 1/ 2/ 3/ 4	12/19/75/44

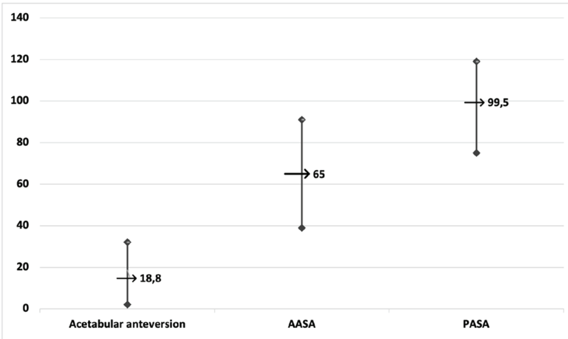

Figure 2. Acetabular measurements

Table 2. Variation according to acetabular measurements and demographic data

	Interobserver reliability				
	Observer A	**Observer B**	**Observer C**	**Intraclass correlation coefficient or Kappa**	**Interpretation**
Acetabular anteversion	18.73±5.4	18.89±5.3	18.78±5.6	0.961 (0.953-0.968)	Perfect
AASA	64.45±8.8	65.21±8.9	65.26±9.2	0.940 (0.928-0.951)	Perfect
PASA	99.9±9.7	99.3±9.9	98.5±10.1	0.917 (0.907-0.929)	Perfect
Lumbar lordosis	32.1±11.5	31.6±11.3	31.4±11.1	0.984 (0.957-0.994)	Perfect
Sacral slop	40.2± 7.7	41± 7.6	41.4± 7.6	0.954 (0.923-0.979)	Perfect
Pelvic tilt	11.4±5.8	10.8±5.3	10.6±5.7	0.988 (0.981-0.997)	Perfect
Pelvic incidence	51±9.7	53.1±9.1	52.2±9.5	0.977 (0.957-0.994)	Perfect
Roussouly classification Type 1/ 2/ 3/ 4	12/19/75/44	12/19/75/44	12/19/75/44	1.000	Perfect

Table 3. Variation according to acetabular measurements and demographic data

		Acetabular version			AASA			PASA		
	Patients	**Mean**	**Std**	**p**	**Mean**	**Std**	**p**	**Mean**	**std**	**p**
Total	150	18.8	5.9		65	8.9		99.4	9.9	
Age										
<40	71	18.4	4.6		63.4	8.3		97.4	9.6	
40-60	46	19.5	7	0.866	65.4	7.6	0.008	100	9.5	0.000
>60	33	18.5	6.7		67.8	11.1		103	10.1	
Gender										
Female	31	19.4	5.4		63	8.8		100	8.7	
Male	119	18.6	6.1	0.087	65.5	8.9	0.020	99.2	10.2	0.427
Side										
Right	150	18.8	5		65.6	8.9		100.4	9	
Left	150	18.8	6.7	0.841	64.4	9	0.181	98.5	10.7	0.087

Table 4. Correlation of the lumbar parameters and acetabular version

	Lumbar lordosis		Pelvic tilt		Sacral slop		Pelvic incidence	
	P değeri	**R değeri**	**P değeri**	**R değeri**	**P değeri**	**R değeri**	**P değeri**	**R değeri**
Acetabular version	0.001*	0.262	<0.001*	0.521*	0.017*	0.194	<0.001*	0.388
ASAA	0.234	-0.098	<0.001*	-0.304	0.234	-0.96	0.002*	-0.246
PASA	0.013*	0.203	<0.001*	0.319	0.054	0.157	<0.001*	0.303

Table 5: Acetabular measurements according to the Roussouly classification

	Tip 1		Tip 2		Tip 3		Tip 4		p
	mean	**sd**	**mean**	**sd**	**mean**	**sd**	**mean**	**sd**	
Acetabular anteversion	14.9	5.1	18.3	5	18.7	4.7	20.1	5.2	0.05*
AASA	65	9.8	68.5	8.3	65.4	9.5	64.8	7.8	0.460
PASA	94.1	7.3	101.8	10	99.4	7.7	103.3	10.2	0.015*

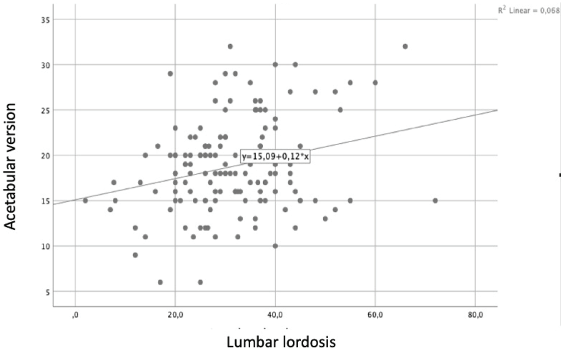

Figure 3. Distribution of acetabular anteversion and pelvic tilt measurements

Pelvic measurements are as follows; pelvic tilt was 10.9±5.3 (range: 2-33), the sacral slope was 41.1±7.5 (range: 20-60), and the pelvic incidence was 52±9.5 (range: 26-87) There was a significant correlation between anteversion and pelvic tilt, sacral slope, pelvic incidence (respectively: p<0.001, p =0.017, p<0.001). Lumbar lordosis and anteversion distribution are shown in **Figure 3.**

Lumbar lordosis of the patients was 31.7±11.3 (range: 2-72) and there was a significant correlation with acetabular anteversion (p=0.001, R value:0.262). Lumbar lordosis and anteversion distribution are shown in **Figure 4.** Correlation analyses between acetabular anteversion and lumbar or pelvic parameters are presented in Table 4. According to Rousouly classification; 12 patients were type 1, 19 patients were type 2, 75 patients were type 3 and 44 patients were type 4 patients. Acetabular measurements according to the Roussouly classification Type 1: 14.9±5.1, Type 2: 18.3±5, Type 3: 18.7±4.7, and Type 4: 20.1±5.2 **(Table 5).** Increasing in anteversion was statistically significant **(Figure 5).**

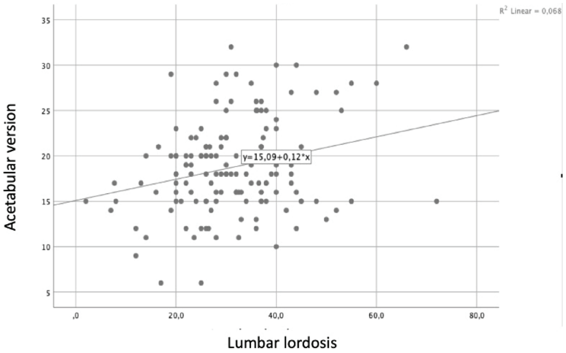

Figure 4. Distribution of acetabular anteversion and lumbar lordosis measurements

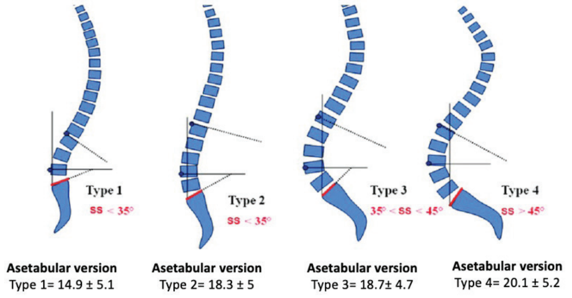

Figure 5. Acetabular anteversion according to Roussouly classification

DISCUSSION

The acetabular version is important in both arthroplasty surgery and the etiology of hip diseases. In our study, the acetabular version was measured and it was aimed to determine the change of acetabular anteversion versus pelvic and lumbar parameters. The acetabular version has a relatively wide range, from 2 to 30, but is affected by both pelvic and lumbar variants.

Measurement of the acetabular version with CT provides more sensitive results than radiography, and Dandachii et al. also found that 3D CT measurements are more sensitive.[18] In determining the acetabular version with CT, the section where the measurement is made is important, the version value increases in measurements towards the caudal. For correct measurement, the assessment should be made in the cross-section where the center of the femoral head is seen. Hitschke et al. showed that measurements made at a distance of 14 mm from the center included high sensitivity and specificity.[19] In dysplastic hips, the cross-section where the measurement will be made is different; various measurement methods have been described.[14]

Although the acetabular version is accepted as 20 degrees, variables studies presented different values and ranges; Perreira et al. 21.3 ± 5.8, Wassilew et al. 18.0 ± 4.7, Tannenbaum et al17 ± 9 antevert.[20-22] The incidence of the retroverted acetabulum is controversial; ranging from 0 to 7% have been reported in the literature. Tannenbaum et al. found the incidence of retrovert acetabulum to be 0% and they emphasized the level of measurement in the study. The retroverted acetabulum was not seen in our study either. Perhaps the incidence of the retroverted acetabulum can be considered as <1%. In our results, the version value showed a high similarity with the contralateral hip and the non-pathological hip can be used for the version in patients. In bilateral CT measurements, the cross-section to be measured for the right or left acetabulum may be different. For correct version measurement, the center of the femoral head associated with the acetabulum to be measured should be considered.

The acetabular version is critical for successful results in hip arthroplasty. Correct placement of the acetabular component is required for successful long-term results in arthroplasty. In the absence of appropriate acetabular placement, an increase in early loosening and dislocation rates is observed.[23] For the position of the acetabular component, Reikerås et al. reported the target zone of the 10°–30° version.[24] According to Lewinneck, the safe zone of the acetabular component is 5°–25° anteversion and 30°–50° inclination in radiographic measurements with manual techniques.[25] However, to determine anteversion in hip arthroplasty, the patient's history (trauma, dysplasia), ethnic and demographic characteristics should be questioned, especially the lumbar and pelvic parameters of the patients should also be examined. William et al. found tilt-adjusted acetabular surgery to be more stable than the classical Lewinneck safe zone.[26] Acetabular inclination/version has been suggested as 40/20 in case of neutral pelvic tilt, 47/34 in posterior pelvic tilt, and 38/9 in case of anterior pelvic tilt.[27] In this suggestion, especially the change in version compared to inclination stands out.

The hip is in a dynamic and integrative movement with both the spine and the pelvis. Hip diseases are affected by sagittal spine balance and spine pathologies. Recent studies have also shown a relationship between lordosis and hip pathologies.[28] A radiographic study designed to evaluate FAI within the context of the lumbosacral junction.[29] Therefore, lumbar spine variables may also affect hip surgery outcomes. In patients with a history of lumbar fusion surgery, more dislocations are observed in the long-term after hip arthroplasty.[30] Increased complications can be expected after hip arthroplasty in patients with a history of spine surgery.[31] Our study examined the relationship between the lumbar spine and hip joint through the acetabular version. Although there was a significant increase in the hip version with the increase in Roussouly classification, a correlation was observed between lumbar lordosis and the acetabular version. We recommend knowing the lumbar typing and lordosis in the planning of primary hip arthroplasty surgery.

Limitation

This study has some limitations. The first limitation is that this study included participants in a certain region. Another limitation is that the measurements are made only with supine CT, they do not include external radiological imaging methods and dynamic evaluations are not performed. However, the measurements were planned and standardized under the literature and were made by three orthopedics and traumatology doctors.

CONCLUSION

The acetabular anteversion value is in a wide range, similar to that of the contralateral hip, and does not vary with age and gender. Lumbar and pelvic parameters have positive correlations with acetabular anteversion.

Ethics Committee Approval: The study was approved by the Local Ethics Committee in Kecioren Health Practice and Research Hospital (2021-10).
Conflict of Interest: None.
Funding: None.
Informed Consent: Consent was not obtained because of the retrospective nature of the study.

REFERENCES

1. Beck M, Kalhor M, Leunig M et al. Hip morphology influences the pattern of damage to the acetabular cartilage Femoroacetabular impingement as a cause of early osteoarthritis of the hip. J Bone Joint Surg Br 2005; 87B: 1012–8. https://doi.org/10.1302/0301-620X.87B7.15203
2. Dolan MM, Heyworth BE, Bedi A, et al. CT reveals a high incidence of osseous abnormalities in hips with labral tears. Clin Orthop Relat Res 2011; 469: 831–8. https://doi.org/10.1007/s11999-010-1539-6
3. To¨nnis D, Heinecke A. Current concepts review - acetabular and femoral anteversion: relationship with osteoarthritis of the hip. J Bone Jt Surg 1999; 81: 1747–70. https://doi.org/ 10.2106/00004623-199912000-00014

4. Gürsan O, Açan AE, Asma A, Hapa O. Labral tears with axial plane disorders. Jt Dis Relat Surg. 2020;31(1):109-14. https://doi.org/10.2106/00004623-199912000-00014

5. Murphy WS, Yun HH, Hayden B, Kowal JH, Murphy SB. The safe zone range for cup anteversion is narrower than for inclination in THA. Clinical orthopedics and related research, 2018, 476(2), 325. https://doi.org/10.1007/s11999.0000000000000051

6. Daines BK, Dennis DA. The importance of acetabular component position in total hip arthroplasty. Orthopedic Clinics of North America, 2012, 43, e23–e34. https://doi.org/ 10.1016/j.ocl.2012.08.002

7. Suzuki D, Nagoya S, Takashima H, Tateda K, Yamashita T. Three-dimensional orientation of the acetabulum. Clin Anat 2017;30:753e60. https://doi.org/10.1002/ca.22945

8. Krebs V, Incavo SJ, Shields WH. The anatomy of the acetabulum: what is normal? Clin Orthop Relat Res 2009;467:868e75. https://doi.org/10.1007/s11999-008-0317-1

9. Klasan A, Neri T, Sommer C, Leie MA, Dworschak P, Schofer MD, Heyse TJ. Analysis of acetabular version: Retroversion prevalence, age, side and gender correlations. J Orthop Translat. 2019 Feb 14;18:7-12. https://doi.org/10.1016/j.jot.2019.01.003

10. Homma Y, Ishii S, Yanagisawa N et. al. Pelvic mobility before and after total hip arthroplasty. Int. Orthop. 2020, 1–8. https://doi.org/ 10.1007/s00264-020-04688-6

11. Fritz B, Agten CA, Boldt FK, Zingg PO, Pfirrmann CWA, Sutter R. Acetabular coverage differs between standing and supine positions: a model-based assessment of low-dose biplanar radiographs and comparison with CT. Eur Radiol. 2019 Oct;29(10):5691-5699. https://doi.org/ 10.1007/s00330-019-06136-5

12. Roussouly P, Gollogly S, Berthonnaud E, Dimnet, J. Classification of the normal variation in the sagittal alignment of the human lumbar spine and pelvis in the standing position. Spine, 2005, 30(3), 346-353. https://doi.org/ 10.1097/01.brs.0000152379.54463.65

13. Paul S, Singh S, Raja BS, Mishra D, Kalia RB. CT Based Analysis of Acetabular Morphology in Northern Indian Population: A Retrospective Study. Indian Journal of Orthopedics,2020 1-8. https://doi.org/10.1007/s43465-020-00267-4

14. Anda S, Terjesen T, Kvistad KA. Computed tomography measurements of the acetabulum in adult dysplastic hips: which level is appropriate? Skeletal Radiol. 1991;20(4):267-71. https://doi.org/10.1007/BF02341662.

15. Karademir M, Karavelioğlu E, Boyacı MG, Eser O. Omurgada sagittal dengenin önemi ve spinopelvik parametreler. The Journal Of Turkish Spinal Surgery, cilt.25, sa.2, ss.139-148. 2014. https://hdl.handle.net/20.500.12462/4366

16. Koo TK, Li MY. A Guideline of Selecting and Reporting Intraclass Correlation Coefficients for Reliability Research. J Chiropr Med. 2016 Jun;15(2):155-63. https://doi.org/10.1016/j.jcm.2016.02.012

17. Landis JR, Koch GG. The measurement of observer agre ment for categorical data. Biometrics, 1977; 33: 159.

18. Dandachli W, Ul Islam S, Tippett R, Hall-Craggs MA, Witt JD. Analysis of acetabular version in the native hip: comparison between 2D axial CT and 3D CT measurements. Skeletal Radiol. 2011 Jul;40(7):877-83. https://doi.org/10.1007/s00256-010-1065-3

19. Nitschke A, Petersen B, Lambert JR, Glueck DH, Jesse MK, Strickland C, Mei-Dan O. Validation of neck axis distance as a radiographic measure for acetabular anteversion. J Hip Preserv Surg. 2016 Jan 28;3(1):72-8. https://doi.org/10.1093/jhps/hnv082

20. Perreira AC, Hunter JC, Laird T, Jamali AA. Multilevel measurement of acetabular version using 3-D CT-generated models: implications for hip preservation surgery. Clin Orthop Relat Res 2011;469:552e61. https://doi.org/10.1007/s11999-010-1567-2.

21. Wassilew GI, Heller MO, Janz V, Perka C, Mu¨ller M, Renner L. High prevalence of acetabular retroversion in asymptomatic adults: a 3D CT-based study. Bone Joint Lett J 2017;99-B: 1584e9. https://doi.org/10.1302/0301-620X.99B12.37081

22. Tannenbaum E, Kopydlowski N, Smith M, Bedi A, Sekiya JK. Gender and racial differences in focal and global acetabular version. J Arthroplasty 2014; 29:373e6. https://doi.org/10.1016/j.arth.2013.05.015

23. Okanoue Y, Ikeuchi, M, Takaya S, Izumi M, Aso K, Kawakami T. Chronological Changes in Functional Cup Position at 10 Years after Total Hip Arthroplasty. HIP Int. 2017, 27, 477–482. https://doi.org/ 10.5301/hipint.5000487

24. Reikerås O, Gunderson RB. Components anteversion in primary cementless THA using straight stem and hemispherical cup: A prospective study in 91 hips using CT-scan measurements. Orthop Traumatol Surg Res,2011 97(6):615–621 https://doi.org/ 10.1016/j.otsr.2011.02.014.

25. Lewinnek GE, Lewis JL, Tarr R, Compere CL, Zimmerman JR. Dislocations after total hip-replacement arthroplasties. J Bone Joint Surg Am 1978;60:217–20.

26. Murphy WS, Yun HH, Hayden B, Kowal JH, Murphy SB. The Safe Zone Range for Cup Anteversion Is Narrower Than for Inclination in THA. Clin Orthop Relat Res. 2018 Feb;476(2):325-335. https://doi.org/10.1007/s11999.0000000000000051.

27. Pierrepont J, Hawdon G, Miles BP, Connor BO, Baré J, Walter LR, Marel E, Solomon M, McMahon S, Shimmin AJ. Variation in functional pelvic tilt in patients undergoing total hip arthroplasty. Bone Joint J. 2017 Feb;99-B(2):184-191. doi: 10.1302/0301-620X.99B2.BJJ-2016-0098.R1. https://doi.org/10.1302/0301-620X.99B2.BJJ-2016-0098.R1

28. Fader RR, Tao MA, Gaudiani MA, et al. The role of lumbar lordosis and pelvic sagittal balance in femoroacetabular impingement, Bone Joint J. 2018;100-b:1275-9. https://doi.org/10.1302/0301-620X.100B10.BJJ-2018-0060.R1.

29. Nabi V, Demirkiran HG, Atilla B, Tokgozoglu M, Caglar O. The prevalence of radiographic femoroacetabular impingement morphology in adolescent spine patients. Medicine, 2021, 10(2), 524-8. https://doi.org/10.5455/medscience.2021.04.108

30. Buckland AJ, Puvanesarajah V, Vigdorchik J, Schwarzkopf R, Jain A, Klineberg EO, Hart RA, Callaghan JJ, Hassanzadeh H. Dislocation of a primary total hip arthroplasty is more common in patients with a lumbar spinal fusion. Bone Joint J. 2017 May;99-B(5):585-591. https://doi.org/10.1302/0301-620X.99B5.BJJ-2016-0657.R1

31. Sing, D.; Barry, J.J.; Aguilar, T.U.; Theologis, A.A.; Patterson, J.; Tay, B.; Vail, T.P.; Hansen, E.N. Prior Lumbar Spinal Arthrodesis Increases Risk of Prosthetic-Related Complication in Total Hip Arthroplasty. J. Arthroplast. 2016, 31 (Suppl. S9), 227. e1–232.e1. https://doi.org/10.1016/j.arth.2016.02.069.