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ORIGINAL ARTICLE

EVALUATION OF INTRA- AND INTEROBSERVER RELIABILITY IN THE ASSESSMENT OF ALPHA ANGLE IN FEMOROACETABULAR IMPINGEMENT SYNDROME (FAI)

OCENA WIARYGODNOŚCI WEWNĄTRZ- I MIĘDZYOBSERWACYJNEJ W OCENIE KĄTA ALFA W KONFLIKCIE UDOWO-PANEWKOWYM (FAI)

Antoni Raciborski Król[1,A-D], Jakub Wąsik[1,B-D], Tomasz Noras[1,B], Katarzyna Kwas[2,A], Radosław Grabowski[1,A,E], Marcin Domżalski[1,A,C,E-F]
[1]Department of Orthopaedics and Traumatology, University Clinical Hospital No. 2 of the Medical University of Lodz, Medical University of Lodz, Poland
[2]Department of Operative Gynaecology and Oncology, Medical University of Lodz, Poland
A – Research concept and design
B – Collection and/or assembly of data
C – Data analysis and interpretation
D – Writing the article
E – Critical revision of the article
F – Final approval of the article

ABSTRACT

Introduction

Femoroacetabular Impingement Syndrome (FAI) is a multifactorial hip disorder that originates from abnormal contact between the femoral head-neck and the acetabulum, ultimately leading to joint damage. The most precise definition of FAI, established in 2016, describes the condition as a motion-related hip disorder characterised by pain symptoms, restricted mobility and characteristic imaging findings. FAI manifests in three main morphological types: Cam, where bone growth on the femur causes abnormal head-neck offset, Pincer, where the acetabulum excessively covers the femoral head and Mixed which contains features of both previous mentioned types. The alpha angle is a key radiographic measure used to diagnose Cam-morphology FAI. However, studies have demonstrated that there is considerable variability in the reliability of its measurement, with intraobserver reliability typically higher than interobserver consistency.

Aim

The aim of the study was to determine variability of alpha angle measurements on radiographs, with use of the inter- and interobserver reliability in assessing the alpha angle of the hip joint.

Material and methods

A retrospective observational study was conducted on 72 radiographs of adult patients diagnosed with FAI who had undergone arthroscopic osteoplasty of the hip joint. The patients' axial radiographs were evaluated by three independent investigators. Measurements were taken preoperatively and postoperatively in two probes before and after the blinding process was initiated.

Author responsible for correspondence:
Antoni Raciborski Król 0009-0006-4371-9068
Department of Orthopaedics and Traumatology, University Clinical Hospital No. 2 of the Medical University of Łódź, Medical University of Łódź, Medical University of Łódź, Żeromskiego 113, 90-549, Łódź, Poland;
Email: antoni.raciborski-krol@stud.umed.lodz.pl

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Results
Value of Inter-Observer Reliability of alpha angle measurements in preoperative group (0.44–0.62) as well as in postoperative group (0.48–0.50) is moderate. Value of intra class reliθ ability come with significant variability, as is lower in postoperative group (0.46–0.89) and higher in postoperative group (0.79–0.96).

Conclusions
Constituency of measurements of alpha angle might by influenced by lack of observer's experience.

Keywords: femoroacetabular impingement syndrome, alpha angle, hip arthroscopy

STRESZCZENIE
Wprowadzenie
Konflikt udowo-panewkowy (ang. Femoroacetabular Impingement Syndrome, FAI) jest wieloczynnikowym schorzeniem stawu biodrowego. Charakteryzującą się objawami bólowymi, ograniczoną ruchomością i charakterystycznymi wynikami badań obrazowych. FAI objawia się w trzech głównych typach morfologicznych: Cam, gdzie wzrost kości na kości udowej powoduje nieprawidłowy kontakt między głową a szyjką, Pincer, gdzie panewka nadmiernie pokrywa głowę kości udowej i Mieszany, który zawiera cechy obu poprzednich wymienionych typów. Kąt alfa jest kluczową miarą radiograficzną stosowaną do diagnozowania FAI o morfologii Cam. Badania wykazały jednak, że istnieje znaczna zmienność w wiarygodności jego pomiaru, przy czym wiarygodność wewnątrzobserwacyjna jest zwykle wyższa niż spójność międzyobserwacyjna.

Cel badania
Celem badania było określenie zmienności pomiarów kąta alfa na radiogramach, z wykorzystaniem wiarygodności wewnątrz- i międzyklasowej w ocenie kąta alfa w stawie biodrowego.

Materiał i metody
Retrospektywne badanie obserwacyjne przeprowadzono na 72 osiowych radiogramach dorosłych pacjentów ze zdiagnozowaną FAI, którzy przeszli artroskopową osteoplastykę stawu biodrowego. Pomiary wykonano przed i po operacją, w dwóch próbach przed i po zaślepieniu.

Wyniki
Wartość wiarygodności międzklasowej pomiarów kąta alfa w grupie przedoperacyjnej (0,44–0,62), jak również w grupie pooperacyjnej (0,48–0,50) jest umiarkowana. Wartość wiarygodności wewnątrzklasowej charakteryzuje się znaczną zmiennością, ponieważ jest niższa w grupie pooperacyjnej (0,46- 0,89) i wyższa w grupie pooperacyjnej (0,79–0,96).

Wnioski
Na zgodność pomiarów kąta alfa może mieć wpływ brak doświadczenia obserwatora.

Słowa kluczowe: konflikt udowo-panewkowy, kąt alfa, artroskopia biodra

Introduction

Femoroacetabular Impingement Syndrome (FAI) is likely multifactorial femoral head-neck deformity which leads to the abnormal contact between the proximal femur and the acetabulum and progressive chondrolabral injury (Grantham and Philippon, 2019). The precise aetiology remains uncertain.

The most accurate definition of FAI was published in the Warwick Consensus in 2016, which described FAI as a "motion-related clinical disorder of the hip with a triad of symptoms, clinical signs, and imaging findings." It represents symptomatic premature contact between the proximal femur and the acetabulum (Griffin *et al.,* 2016) FAI can be divided into two main morphological types: Cam and Pincer. The Cam morphology is characterised by a bone superstructure on the proximal femur, which leads to an abnormal neck-head offset. In contrast, the Pincer morphology is defined by bone over coverage of the femoral head by the acetabulum. A mixed morphology can be observed when characteristic of both impingements are present (Ganz *et al.,* 2003).

In FAI, the alpha angle is a crucial radiographic measure, with studies indicating varying degrees of intra- and interobserver reliability. The alpha angle is defined as the angle formed between two lines, one of which originates at the centre of the femoral head and the other of which leads to the centre of the femoral neck, with the line between them extending to the edge of the acetabulum. The measurement of the alpha angle is of great importance in the diagnosis of Cam- morphology FAI. An increased alpha angle is indicative of a potential deformity.

Clohisy *et al.* highlighted that the reliability of radiographic evaluations of the hip, including the alpha angle, is often limited. It was observed that while intraobserver reliability tends to be higher, interobserver reliability can be significantly lower, reflecting the challenges in consistent measurements across different observers (Clohisy *et al.,* 2009). This observation aligns with findings from Shimodaira research, who reported nearly perfect agreement for the alpha angle in their study yet acknowledged that other studies have shown lower interobserver reliability compared to intraobserver reliability(Shimodaira *et al.,* 2021). This discrepancy suggests that while individual observers may consistently measure the alpha angle, variability can arise when different observers are involved. Further supporting the reliability of the alpha angle measurement. High reliability is crucial for clinical practice, as it ensures that the measurements can be trusted for diagnostic and treatment decisions.

The primary aim of this study was to assess the interobserver and interobserver variability of alpha angle measurement. The secondary aim was to determine changes in the alpha angle prior to and following hip arthroscopic osteoplasty.

Materials and methods

The group of patients on whom this study was conducted was admitted between 2014 and 2018 to the Department of Orthopaedics and Traumatology in Military Medical Academy Memorial Teaching Hospital of the Medical University of Lodz – Central Veterans' Hospital. The Inclusion criteria were as follows.: adult patients (over 18 years old), diagnosed with FAI Cam or Mixed morphology, qualified for referrals for arthroscopic treatment hip arthroscopic osteoplasty.

Exclusion criteria included prior advanced osteoarthritis or evidence of post-traumatic deformity, Legg-Calve-Perthes disease, osteonecrosis or hip dysplasia, poor quality of radiograph, lack of control photo.

A total of 52 patients (9 females and 43 males), with an average age of 41 years (ranging from 19 to 66), were included in this study. There were 26 hips on the right side and 26 on the left side. From these group 36 cases were assessed both before and after surgical intervention.

Standing axial radiographs were acquired from the hospital's database of alpha angles in affected sides before and after the surgery with an additional blinded trial.

The blinding was performed by that one of the researchers that did not measure the alpha angle, removed any personal information visible in the photo and changed the title of the photo so as not to suggest whether the radiograph was taken before or after the operation. The radiographs were evaluated by medical students following training in assessment of alpha angle by an experienced orthopaedic surgeon, who also supervised them during data collection. For the assessment of radiographs the RadiAnt DICOM Viewer (URL: https://www.radiantviewer.com) and Horos software programs were used. Statistical analysis was performed using the Statistica 13 program.

The alpha angle is defined as the angle between a line drawn in the long axis of the femoral neck and a connecting line in the centre of the femoral head, with the point located where the head loses sphericality. It was measured using an axial pelvic view (Fig. 1). For the purpose of statistical analysis the Intraclass Corelation Coefficient (ICC) and Student's T-test were performed. For A p-value of < 0.05 was considered statistically significant.

Results

Preoperative alpha angle

For Observer 1 all the measurements of alpha angle before surgery showed normal distribution.

The mean alpha angle in a blinded probe was 74.21° ± 8.527, whereas in a not blinded series – 72.584° ± 6.192.

For Observer 2, a blinded probe presented normal distribution whereas the unblinded probe did not. The mean alpha angle in a blinded probe was 77.697° ± 6.295. In not blinded series the median alpha angle was 77.30°.

For Observer 3 all the measurements of alpha angle before surgery showed normal distribution.

The mean preoperative alpha angle in a blinded probe was 72.740° ± 7.864. In the not blinded series the mean alpha angle was 73.03° ± 8.45.

The analysis revealed that Inter-Observer Reliability of alpha angle measurements for not blinded group before operation was 0.44 and after blinding trial it acquired 0.62 (Table 3.). Intra-Observer Reliability of alpha angle measurements for Observer 1 – 0.46; for Observer 2 – 0.66; for Observer 3 – 0.89 (Table 4.).

Postoperative alpha angle

For Observer 1 all the measurements had normal distribution. The mean alpha in the blinded group angle was 60.72° ± 8.626. In the not blinded series the mean alpha angle was 56.32° ± 6.414.

The measurements of Observer 2 also showed a normal distribution. The mean alpha angle in the blinded group was 63.83° ± 8.26. In the not blinded series the mean alpha angle postsurgically was 62.33° ± 8.839.

For Observer 3 the measurements did not acquire normal distribution. The median alpha angle in the blinded group was 53.85°. In the not blinded series, the median alpha angle postsurgically was 56.90°.

The analysis revealed that Inter-Observer Reliability of alpha angle measurements for not blinded group before operation was 0.48 and after blinding trial it acquired 0.50 (Table 3.)

Intra-Observer Reliability of alpha angle measurements for Observer 1 – 0.90; for Observer 2 – 0.79; for Observer 3 – 0.96 (Table 4.).

Discussion

The primary objective of this study was to ascertain the intra- and interobserver reliability of alpha angle measurements, given its critical role in the accurate diagnosis and treatment planning of FAI. The findings revealed that inexperienced observers who are not radiology specialists exhibited moderate interobserver reliability for both preoperative (0.44–0.62) and postoperative measurements (0.48–0.50), as presented in Table 3. The variability of these values was found to range from moderate to excellent, as demonstrated in Table 4. The secondary objective of this study was to observe the changes in the alpha angle following arthroscopic osteoplasty.

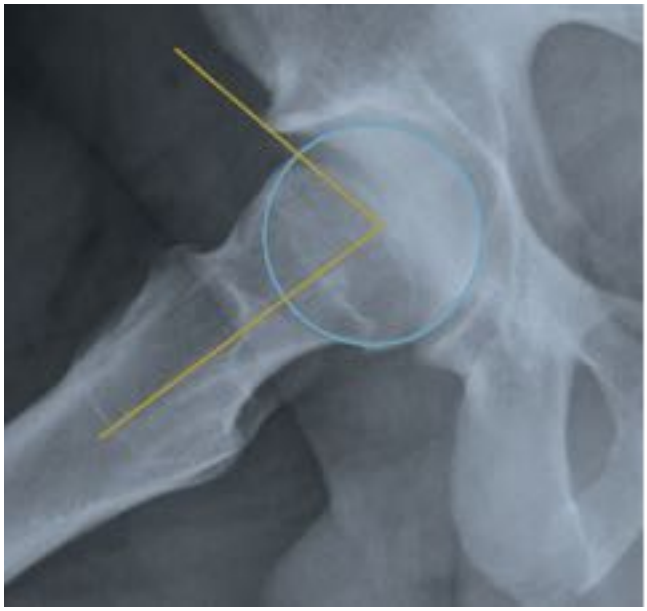

Figure 1. Measurement of alpha angle on radiograph

Table 1. Measurements of the mean/median preoperative alpha angle.

	Blinded	**p-value**	**Not blinded**	**p-value**
1st Observer	74.21˚ ± 8.527	0.6*	72.584˚ ± 6.192	0.328*
2nd Observer	77.697˚ ± 6.295	0.348*	77.10˚ †	0.011
3rd Observer	72.740˚ ± 7.864	0.504*	73.03˚ ± 8.45	0.444*

† – median * – normal distrubtion

Table 2. Measurements of the mean/median postoperative alpha angle.

	Blinded	**p-value**	**Not blinded**	**p-value**
1st Observer	60.72˚ ± 8.626	0.6*	56.32˚ ± 6.414	0.754*
2nd Observer	63.83˚ ± 8.26	0.505*	62.33˚ ± 8.839	0.379*
3rd Observer	53.85˚ †	0.005	56.90˚ †	0.019

† – median * – normal distrubtion

Table 3. Value of Inter-Observer Reliability of alpha angle measurements.

Inter-Observer reliability	**Preoperative**	**Postoperative**
Not Blinded	0.44	0.48
Blinded	0.62	0.50

Table 4. Value of Intra-Observer Reliability of alpha angle measurements.

Intra-Observer reliability	**Preoperative**	**Postoperative**
1st Observer	0.46	0.90
2nd Observer	0.66	0.79
3rd Observer	0.89	0.96

The results obtained from the measurements revealed that the alpha angle values were higher in the postoperative group compared to the preoperative group for each probe.

The reliability of alpha angle can significantly influence clinical outcomes, as variations in interpretation can lead to misdiagnosis or inappropriate treatment strategies. A study by de Sa *et al.* established that an alpha angle greater than 55˚ is indicative of Cam morphology, reinforcing the importance of accurate measurement (de Sa *et al.,* 2014).

Stähelin *et al.* demonstrated that patients with alpha angle higher than 50˚ did not differ from those with lower values of alpha angle in terms of clinical outcome measure in the six-months period (Stähelin *et al.,* 2008). Moreover, the study conducted by Philippon *et al.* illustrated that the over a five-year period, there were no differences in patient-related outcomes between groups with postoperative angles greater than 55˚ and those with alpha angles less than 55˚, based on a questionnaire including the modified Harris Hip score (MHHS), WOMAC, HOS ADL, HOS Sport, SF12 and patient satisfaction (Philippon *et al.,* 2007). It is noteworthy that they employed a similar methodology to ours for measuring alpha angle on plane radiographs.

However, the interpretation of the alpha angle can be influenced by the imaging modality used. For instance, while plain radiographs are commonly utilized, advanced imaging techniques such as MRI and CT provide more detailed assessments of hip morphology and may yield different alpha angle measurements (Barton *et al.,* 2011).

Studies have shown that the alpha angle exhibits high intraobserver reliability, with intraclass correlation coefficients (ICCs) often exceeding 0.80, indicating good agreement (Konan, Rayan and Haddad, 2010; Schottel *et al.,* 2014) For instance, it was reported that the ICC for intraobserver reliability of the alpha angle was 0.88, suggesting that experienced radiologists can consistently reproduce their measurements (Konan, Rayan and Haddad, 2010).

This high level of reliability is crucial for clinical practice, as it ensures that a single observer can confidently assess the alpha angle over time without significant variability. On the other hand, a study by Wong *et al.* evaluated hip radiographs and reported poor inter-reader agreement of 0.33 (Wong *et al.,* 2021).

Conversely, interobserver reliability tends to be lower than intraobserver reliability, which is a common finding in radiographic assessments.

What can be observed in paper published by Mast *et al.* on hip radiographs where the alpha angle measurements came with interrater ICC of 0.83 and the intrarater ICC for Observers were 0.98 and 0.96 (Mast *et al.,* 2011). Our results especially that of postoperative group show the same tendency.

Similar results were obtained by Barlow *et al.* in which three independent observers evaluated 50 MRIs of patients complained of hip pain (Barlow *et al.,* 2014). They achieved interrater reliability of 0.67, and obtained better intrarater reliability of 0.84.

For this deduction contract the paper published by Lohan *et al.* in which they concluded that alpha angle has poor intra observer variability between each measurement, up to 30% of mean value (Lohan *et al.,* 2009). The corresponding conclusions were reached in another study. During comparing various methods of measuring radiograph parameters it was observed that alpha angle has moderate interobserver agreement between each probe, ICC ranging from 0.33–0.47 (Carlisle *et al.,* 2011).

However, low value of agreement between each Observer demonstrates that the measurement of the alpha angle may be subjective if taken by inexperienced physicians. Furthermore, evident differences in intraclass before and after surgery shows inconsistence in measurements. Higher intra-class value in postoperative group suggest that it might be easier to find measure alpha angle in postoperative conditions. This discrepancy underscores the importance of standardized measurement protocols and training

for radiologists and orthopaedic surgeons to enhance consistency in alpha angle assessments. Furthermore, a study by Neeple *et al.* corroborated these findings, indicating that qualitative evaluations without quantitative measurements often yield poor reliability (Nepple *et al.,* 2014).

This variability highlights the necessity for clinicians to consider the imaging technique when interpreting alpha angle values.

In the present study, no additional methods were employed to measure the alpha angle beyond those available in the software utilized for the evaluation of radiographs.

An intriguing paper was reported by Lai *et al.,* in which a numerical method was employed to measure the alpha angle with greater accuracy. This involved determining curve fitting of the femoral neck, circle fitting of the femoral head, and the determination of femoral neck axis. The results demonstrate that the inter-rater ICC in radiographs was 0.905 and the intra-rater ICC was 0.892 (Lai *et al.,* 2019).

The use of additional methods in alpha angle measurements was investigated by Bouma *et al.* They compared the three-point and anatomic methods for measuring the alpha angle, which defines the femoral neck axis by connecting the centres of three circles projected over the neck contour. Therefore, in comparison to the anatomic method, the 3-point method had the effect of equalising alpha angle measurement: high values obtained with the anatomic method were lower with the 3-point method, and vice versa for low values (referencing interval was 30–66˚ and 32–58˚ for the anatomic and 3-point method, respectively) (Bouma *et al.,* 2014). Furthermore, attempts are being made to automate measurements that demonstrate a high degree of agreement with manual measurements (Faber *et al.,* 2021). The discrepancies in the repeatability of the measurements indicate that drawing conclusions based on a single measurement of the alpha angle may be too generalised. Our study has demonstrated these findings based on conventional methods. However, it is also necessary to determine whether these results can be replicated using supported or automated methods, which are currently under investigation.

Limitations

Although the study presents an innovative approach to the topic, it is not free from limitations. Firstly, the researchers did not have much experience in assessing radiographs and were supervised by more experienced orthopaedic surgeons. The second limitation was the number of patients and lack of control group due to the fact that only patients treated for FAI were included into the study.

Conclusions

The results indicated that the measurement of the alpha angle is associated with a moderate degree of variability. Inexperienced observers have been observed to demonstrate inconsistent measurement practices with regard to the alpha angle. What is intriguing, the measurements of postoperative alpha angle comes with higher realisability between researchers. Future research should focus on developing standardized protocols and exploring the integration of advanced imaging techniques to further refine the assessment of the alpha angle in clinical practice.

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