Fall 8-13-2016

Dunn Lateral View is the Most Predictable Plain Film Radiograph for Demonstrating a Cam Lesion in the Initial Diagnosis of Femoroacetabular Impingement

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Recommended Citation
Hansen, Rory J., "Dunn Lateral View is the Most Predictable Plain Film Radiograph for Demonstrating a Cam Lesion in the Initial Diagnosis of Femoroacetabular Impingement" (2016). School of Physician Assistant Studies. 564.
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Dunn Lateral View is the Most Predictable Plain Film Radiograph for Demonstrating a Cam Lesion in the Initial Diagnosis of Femoroacetabular Impingement

Abstract

Background: Femoroacetabular impingement (FAI) has become increasingly recognized as a pathologic entity in individuals with hip pain leading to secondary osteoarthritis. Radiographic imaging is vitally important to the diagnosis of FAI. There is controversy over the most effective imaging techniques required to appreciate a cam lesion in lateral view plain film radiographs. Both Dunn and frog lateral views are used to appreciate cam lesions and research debates which view is most effective in measuring the degree of asphericity about the femoral head-neck junction. It has been proposed that a Dunn lateral view be taken. This has led clinical researchers to ask the following question: Is Dunn lateral the most predictable view in plain film radiographic demonstration of a cam lesion?

Methods: An exhaustive search of appropriate medical literature was conducted using MEDLINE-Ovid, CINAHL, and Web of Science, using the keywords: femoroacetabular impingement, Dunn lateral view, frog lateral view, radiographic, alpha angle, cam lesion, and cam impingement. Articles which met the clinical question and inclusion criteria of human participants and articles written in the English language were evaluated for quality using Grading of Recommendations, Assessment, Development and Evaluation (GRADE).

Results: Four studies met inclusion criteria. A retrospective study using 21 desiccated femurs compared six radiographic projections assessing cam lesion findings and concluded the Dunn lateral view to be most sensitive and specific in showing femoral head-neck asphericity. Another study reviewed radiographs of 61 hips treated for cam impingement and 24 asymptomatic control hips for accurate visualization of a cam lesion. They found the frog lateral view to be most accurate film compared to AP pelvis and cross-table lateral views. A retrospective study acquired CT arthrograms from 15 previously diagnosed patients with cam FAI. These were compared with a control group of 15 cadaveric femurs that were matched with height, weight, and BMI of the retrospect patients. Digitally reconstructed radiographs (DRR) were made in five views to correlate with the CT images of the FAI and control groups and alpha angles were measured showing the Dunn view as the highest correlation with the superior measurements of the CT arthrogram. The Dunn view was also considered superior to the frog lateral and AP views in cam lesion demonstration. Another retrospective study assessed the diagnostic sensitivity of Dunn view and cross-table lateral view in the evaluation of 60 cases of cam FAI by comparison with Radial MRI. The sensitivity for cam deformity was 96.4% in the Dunn view compared to 70% in the cross-table lateral view, showing the Dunn view was most appropriate for first line cam impingement diagnostics.

Conclusion: Studies suggest that the 45-degree Dunn lateral view is superior to other lateral views on plain film radiograph in the initial evaluation of cam lesions associated with FAI. Research is currently debated with regard to frog lateral views being equally as efficient. Further research using a large-scale retrospective comparison study should be performed in order to further validate the claim that the Dunn lateral view is superior to all lateral views in the initial demonstration of a cam lesion.

Keywords: Femoroacetabular impingement, cam impingement, cam lesion, alpha angle, Dunn lateral view, frog lateral view, cross-table lateral view.

Degree Type
Capstone Project
First Advisor
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Second Advisor
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Keywords
femoral acetabular impingment

Subject Categories
Medicine and Health Sciences

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Dunn Lateral View is the Most Predictable Plain Film Radiograph for Demonstrating a Cam Lesion in the Initial Diagnosis of Femoroacetabular Impingement

Rory Hansen

A Clinical Graduate Project Submitted to the Faculty of the School of Physician Assistant Studies Pacific University Hillsboro, OR For the Masters of Science Degree 2016

Faculty Advisor: David Keene, PA-C
Clinical Graduate Project Coordinator: Annjanette Sommers, PA-C, MS
|| Biography ||

Rory Hansen is originally from Oceanside, California and received his Bachelor’s degree from Utah Valley University, in 2013, with a degree in Exercise Science. His clinical background includes four years of experience as an EMT as well as two years working as a Physician’s Alternate for a plasmapheresis center. He is interested in pursuing a career in orthopedic surgery.
**Abstract**

**Background:** Femoroacetabular impingement (FAI) has become increasingly recognized as a pathologic entity in individuals with hip pain leading to secondary osteoarthritis. Radiographic imaging is vitally important to the diagnosis of FAI. There is controversy over the most effective imaging techniques required to appreciate a cam lesion in lateral view plain film radiographs. Both Dunn and frog lateral views are used to appreciate cam lesions and research debates which view is most effective in measuring the degree of asphericity about the femoral head-neck junction. It has been proposed that a Dunn lateral view be taken. This has led clinical researchers to ask the following question: Is Dunn lateral the most predictable view in plain film radiographic demonstration of a cam lesion?

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**Conclusion:** Studies suggest that the 45-degree Dunn lateral view is superior to other lateral views on plain film radiograph in the initial evaluation of cam lesions associated with FAI. Research is currently debated with regard to frog lateral views being equally as efficient. Further research using a large-scale retrospective comparison study should be performed in order to further validate the claim that the Dunn lateral view is superior to all lateral views in the initial demonstration of a cam lesion.

**Keywords:** Femoroacetabular impingement, cam impingement, cam lesion, alpha angle, Dunn lateral view, frog lateral view, cross-table lateral view.
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Table I: Characteristics of Reviewed Studies and GRADE profile

List of Abbreviations

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<tr>
<td>FAI</td>
<td>femoroacetabular impingement</td>
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<td>3D CT</td>
<td>three dimensional computed tomography</td>
</tr>
<tr>
<td>MRI</td>
<td>magnetic resonance imaging</td>
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<tr>
<td>OA</td>
<td>osteoarthritis</td>
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<tr>
<td>DRR</td>
<td>digitally reconstructed radiograph</td>
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<tr>
<td>SD</td>
<td>standard deviation</td>
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<td>BMI</td>
<td>body mass index</td>
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<td>AP</td>
<td>anteroposterior</td>
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<tr>
<td>IR</td>
<td>internal rotation</td>
</tr>
<tr>
<td>SCFE</td>
<td>slipped capital femoral epiphysis</td>
</tr>
<tr>
<td>DRR</td>
<td>digitally reconstructed radiographs</td>
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<td>ICC</td>
<td>intraclass correlation coefficient</td>
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Dunn Lateral View is the Most Predictable Plain Film Radiograph for Demonstrating a Cam Lesion in the Initial Diagnosis of Femoroacetabular Impingement.

BACKGROUND

The concept of femoroacetabular impingement (FAI) has grown exponentially in popularity with increased enthusiasm in orthopedics. FAI is recognized as a pathologic entity in individuals with hip pain leading to secondary osteoarthritis. The underlying anatomic pathology is usually revealed at a young age in patients with FAI (athletic or non-athletic). Specifically, FAI is associated with a pathomechanical hip environment where there is abnormal abutment between the anterolateral femoral head-neck junction and the anterolateral rim of the acetabulum. This repetitive contact leads to impingement lesions. Patho-anatomical growth of the acetabulum is described as a pincer lesion. With flexion of the hip, the labrum is crushed against the acetabulum, leading to pain. A cam lesion is a bony pathology at the femoral head-neck junction that also leads to pathologic movement.

Research has concluded that a cam impingement occurs when the radius of curvature of the femoral head-neck junction exceeds the radius of curvature of the acetabulum. This abutment causes severely reduced internal rotation and adduction about the hip. The cam lesion can be subtle and therefore easily missed in physical examination and initial imaging. Certain plain film radiographic views (described below) are used to catch these subtleties.

The degree of severity of a cam lesion is measured using the alpha angle. An alpha angle is described on axial views, as the angle between a line from the center of the femoral head through the middle of the femoral neck and a line through a point where the contour of the femoral head-neck junction exceeds the radius of the femoral head. This can also be stated as the point where the head of the femur loses its sphericity. An alpha angle of greater than 50-55
degrees is considered the cut-off point to performing further imaging studies with an MRI arthrogram.\textsuperscript{8} A large systematic review by Wright et al\textsuperscript{9} concluded that increased alpha angle is the only FAI prognostic factor associated with the development of early osteoarthritis and a labral tear.

Initial plain film radiographs are used in the diagnosis of FAI.\textsuperscript{2,5} This imaging is vitally important in demonstrating the lesion mentioned above (cam and pincer).\textsuperscript{5} 3D CT reconstruction and MRI are considered the gold standard for evaluation in preoperative settings and non-obvious bony abnormalities in FAI.\textsuperscript{10} Plain radiographic films are still an affordable and accessible tool to be used in conjunction with clinical presentation in the initial evaluation of cam and pincer lesions.\textsuperscript{10,11}

The alpha angle that is used to measure cam lesions is best seen in the lateral view.\textsuperscript{1,2} There is much controversy over the most effective imaging techniques required to appreciate a cam lesion in lateral view radiographs.\textsuperscript{2,10,11,12} Both 45-degree Dunn and frog lateral views are used to appreciate cam lesions and research debates which view is most effective in measuring the degree of asphericity about the femoral head-neck junction.\textsuperscript{2,6,11,12} Given the exponential growth of FAI diagnosis and surgeries, the proper lateral view is extremely important to obtain an accurate alpha angle. Proper radiographic positioning technique is required in order to avoid interposition bias and subtle deviations from desired views.\textsuperscript{11} The 45-degree Dunn lateral view is performed by the patient lying supine with the hip flexed to 45 degrees and abducted 20 degrees. This allows for a parallel view of the anterosuperior aspect of the femoral neck,\textsuperscript{11} leading clinical researchers to ask: is 45-degree Dunn lateral the most predictable view in plain film radiographic demonstration of a cam lesion?
METHODS

An exhaustive search of appropriate medical literature was conducted using MEDLINE-Ovid, CINAHL, and Web of Science articles, using the keywords: femoroacetabular impingement, Dunn lateral view, frog lateral view, radiographic, alpha angle, cam lesion, and cam impingement. The bibliographies from several relevant background articles were used and inclusion/exclusion criteria were applied. Included were systematic reviews on FAI and retrospective studies questioning validity of radiographic findings and FAI. Studies were excluded if researchers didn’t supply data regarding the process of how radiographs were obtained and the position of lateral views obtained. Additionally, conferences, reviews or poster reports that did not report study details were excluded.

Articles which met the clinical question and inclusion criteria of human participants and articles written in the English language were evaluated for quality using Grading of Recommendations, Assessment, Development and Evaluation (GRADE).

RESULTS

The initial search yielded over 223 articles for review. After eliminating duplicates and screening these results for relevant articles using eligibility criteria, four articles met criteria. These articles consisted of three retrospective studies,\textsuperscript{10,11,13} and one diagnostic and retrospective study (see Table I).\textsuperscript{12}

Meyer et al

This was a prognostic level two-one (retrospective) study from 2006 Zurich Switzerland.\textsuperscript{11} Considered a highly regarded study by orthopedic surgeons; it was one of the first studies to compare radiographic views of the femur for purposes of alpha angle and optimal view of cam lesions. Twenty one desiccated femurs were removed from 30 skeletons from the
Institute of Anatomy in Bene, to view with six different radiographic views. Eleven femurs were screened for femoral head asphericity contingent with a cam lesion (anterosuperior asphericity) and 10 were used as control femurs with appropriate sphericity. Excluded femurs included femurs with signs of osteoarthritis (OA; signified by the presence of osteophytes and cysts) and sequela of childhood disease (such as slipped capital femoral epiphysis (SCFE) and Legg-Calve Perths disease). Six plain film radiographs were taken including AP neutral tilt pelvis, cross-table lateral with 15 degrees internal rotation (IR), lateral with 20 degrees IR, cross-table lateral neutral, Dunn with 90 degrees hip flexion, and Dunn with 45 degrees hip flexion and 20 degrees IR. Femoral rotation was determined using the tabletop method to insure proper positioning of the femur and measurements were taken.11

Two blinded examiners performed all radiographs and measurements. Measurements were performed by consensus and not independently. A third examiner independently measured all six radiographic views six months later. This was done to test the intraobserver and interobserver reliability.11

Alpha angles were measured in all six views to determine level of anterosuperior asphericity of the femoral head-neck junction. Angles were measured using Pearson’s correlation according to the Bonferroni correction. Values of p<0.01 were considered statistically significant for a cam lesion. Alpha angles were bigger in the aspherical femurs than in the control femurs for all radiographs. There was a large SD (+16 degrees) on AP showing no difference in the sphericity on AP views. Dunn lateral view with 45 degrees hip flexion was most sensitive in detecting the largest alpha angle in both intraobserver and interobserver correlations (R=0.95 and R=0.88). The differences of two groups in each of the six projections were calculated with
unpaired two-tailed t tests. Differences between six different projections in the same group were calculated using paired two-tailed t tests.\textsuperscript{11}

Limitations to the study included a small sample size of desiccated femurs (11 cam lesion femurs and 10 control femurs). Researchers argued that bony structures were intact on the desiccated specimens and that is all that is seen on plain film radiograph. Patients in a clinical setting have soft tissue and pelvic structures that can cloud the shape of the femur and alpha angle, more than on the specimens studied. The study stated this being another reason for the need of an optimal exposure of the hip on radiograph. Another limitation noted was that researchers only took views of the femur without the associated acetabular structure. This may be problematic secondary to a large percent of FAI patients present with a combination of pincer and cam lesions. Limitations of uncontrolled radiographic technique were stated as a possibility of minimal changes to alpha angle measurements. This limitation, however, is one that must be said with all radiographic evaluation.\textsuperscript{11}

This study was compared with data from Notzli et al\textsuperscript{1} which used MRI imaging to perform alpha angle measurements. MRI use in measurement is seen as superior to plain film but also more costly and with some limitations.\textsuperscript{2} Meyer et al\textsuperscript{11} found their results to be comparable to Notzli et al\textsuperscript{1} in using plain film Dunn 45-degree lateral views (Meyer et al: aspherical femurs=71 degree alpha angle and spherical femurs=50 degree alpha angle compared to Notzli et al: aspherical femurs=74 degree alpha angle and spherical femur=42 degree alpha angle). This study found Dunn 45-degree lateral view to be the most sensitive in demonstrating cam lesions by proving maximum parallel orientation of the femoral neck. This view showed the most accurate angle measurements in the anterosuperior region of the femoral head-neck junction. This is
important because the anterosuperior aspect of the femur is most consistent with typical presentation of a cam lesion.\textsuperscript{2,10,11}

**Harris et al**

This retrospective study\textsuperscript{13} from 2014 looked into the implications, recommendations, and most effective imaging to be used in the diagnosis of FAI. They used both pelvic and proximal femur images from CT arthrograms of 15 patients with previously diagnosed FAI. Those images were compared with 15 control femurs selected from a cadaveric database. The cadaver femurs were disarticulated from the pelvis and had only some articular cartilage intact. These femurs were screened to exclude any OA changes and other bony abnormalities of asphericity. Specimens and CT images that best matched the age, weight, height, and BMI of the FAI patients were selected. None of the specimens were paired.\textsuperscript{13}

CT images of the control femurs were created using Siemens SOMATOM 128 def CT scanner and 3D images were then created with visage imaging technology out of the Siemens images. Using MRL software, the femoral head was identified and measured with regard to radius and sphericity. This was performed by isolating and determining via projecting nodes from the native femoral head to 3D sphere. Asphericity could then be measured using max deviation between the nodes and native sphere.\textsuperscript{13}

Digitally reconstructed radiographs (DRR) were then generated simulating five plain film radiographic views capable of seeing a cam lesion (standing AP, frog lateral, Dunn 45-degree neutral, Dunn 45-degree with abduction, and cross-table lateral). DRRs were created through ray casting which produces images very similar to x-rays. Ray casting was used in order to control the perspective of the images of the CT. It was also said to eliminate bias associated with
positioning error for alpha angle measurement in traditional plain film radiographs. This study did away with intersubject positioning bias and radiation exposure. To note, a separate validation study was performed using DRR and found nearly identical alpha angles with DRR from traditional radiographs. The first DRR was generated from a complete CT image and then a segmentation mask was used to generate a 3D femur model. They were combined to isolate an image set for the femur only. The second DRRs were simulated from a single control volunteer’s CT image. It was rotated to match the five desired views for each projection.\textsuperscript{13}

Due to the nature of DRRs and 3D CT technology, alpha angle was semi-automatic in measurement using a Metlab script. Two observers (imaging scientists trained in FAI) independently measured alpha angles on all five views. The first observer repeated his measurements on two separate occasions. Alpha angles were found to be significantly higher in FAI patients than in control femurs (p< or equal to 0.02).\textsuperscript{13}

Statistical analysis was performed using SPSS v16 IBM technology with significance set at p< or equal to 0.05 with maximum deviation previously compared using a students t-test. Intraobserver and interobserver repeatability of alpha angle measurements was qualified using intraclass correlation coefficient (ICC) with 95% confidence interval. Alpha angles were averaged using measurements one and two from the first observer, and the only measurement from the second observer. The averages were tested against the students t-test for significance. The data from the patient and control groups was combined using the relationship between the alpha angle and maximum deviation using linear regression. The strength of the relationship was assessed with Pearson’s correlation coefficient. Averages and SD for age, weight, height, and BMI were as follows: 26+-7 years, 84+-10 kg, 181+-8 cm, 25+- 3.4kg/m\textsuperscript{2} BMI, respectively. Interobserver (0.72-0.98) and intraobserver (0.86-0.98) ICC scores were almost perfect. Linear
regression also indicated correlations between alpha angle and max deviation significance (as stated above) except for AP views.\textsuperscript{13}

The most significant correlation (r) with alpha angle and max deviation was the 45-degree Dunn with abduction. This view captured the most anterosuperior deviation over all other views measured (r>0.8). Dunn lateral view with neutral did not appreciate cam deformities and frog lateral and cross-table lateral were less significant in their correlation. Researchers stated that if 45-degree Dunn with abduction could not measure a deformity, they would suggest CT or MRI for further diagnostics.\textsuperscript{13}

Limitations were found in this study due to its inherent retrospective nature. The study stated that alpha angle in prospective studies would not add any substantial validity to the study. The way alpha angle was measured also removes positional bias with radiography, but this can in itself be a limitation. The numbers correlated must be considered a best-case result in order to use in a clinical situation, due to how they were received. DRRs are a limitation despite the fact that the alpha angles were nearly identical to plain radiographs. This is because DRRs are not commonly used in clinical application, but alpha angles were still comparable with DRR and plain radiographs. Another limitation is that there was no history with the cadaveric femurs aside from screening for OA changes. This means one cannot rule out possibility that the control subjects had FAI from any single perspective.\textsuperscript{13}

Despite the limitations of the study, alpha angles and demographics fell within range for both FAI and control groups. The 45-degree Dunn view with abduction was superior in demonstrating cam lesions with the 15 FAI femurs. All other lateral views showed some asphericity, but the researchers recommended the 45-degree Dunn lateral with abduction for diagnostic purposes of FAI.\textsuperscript{13}
Clohisy et al

This is a retrospective study\textsuperscript{12} from 2007 claiming the frog lateral view to be an alternate, or possibly an additional view to the 45-degree Dunn lateral. The study reviewed 61 hip radiographs of consecutively diagnosed FAI patients from 2003-2006. These patients were diagnosed using history, physical exam, and radiographic findings. All FAI hips were positive for a cam lesion. All patients had a complete series of radiographs (AP pelvis, frog lateral, and cross-table lateral). Twenty four retrospectively identified patients with complete radiographic series were chosen as a control group. All had no signs of FAI in both physical exam and imaging as they were seen for low back pain. The FAI group had a mean age of 32 (14-53) and gender composed of 26\% female, while the control group had a mean age of 35 (18-49) and gender composed of 46\% males.\textsuperscript{12}

All three films were taken in traditional manner by an orthopedic radiology technician for both groups. The frog lateral view was performed with the patient lying supine and with ipsilateral knee flexed. The sole of the foot rested on the contralateral knee with ER at the hip. This allowed the x-ray beam to directly aim at the femoral head in an AP manner.\textsuperscript{12}

There were two observers who independently reviewed all radiographs. The first observer made measurements on two separate occasions at two weeks apart assessing for intraobserver reliability. Both observers were blinded to patient’s identity and diagnosis. Three measurements were obtained on each radiograph (alpha angle, femoral head neck offset, and sphericity). Alpha angle was measured using the gold standard as described by Notzil et al\textsuperscript{1} and stated earlier in the paper. Notzil et al also noted average alpha angles in patients with FAI at 74 degrees and control at 42 degrees.\textsuperscript{1} Sphericity was measured using a circular template about the femoral head (similar to alpha angle) with abnormalities calculated off of the template. Femoral head-neck
offset was calculated using methods described by Eijer et al\textsuperscript{14} for cross-table lateral views (not statistically significant) which has been shown to be inferior to both frog and Dunn lateral views.\textsuperscript{10,12,13}

ICC was used in assessing intra and interobserver reliability of both alpha angle and head-neck offset measurements. Kappa coefficient was used for head sphericity. Intra and interobserver reliability testing showed frog lateral as the most reliable for reader and alpha angle scores while cross-table lateral received the weakest ICC scores. The mean of the measurements were used in analysis. Age and gender were compared using chi square and unpaired t-tests. Unpaired t-tests were used in comparing the groups for head-neck offset and alpha angle. Paired t-tests were used for the different radiographic views in each group. Comparison of proportion of disagreement between groups for sphericity was performed using chi square and Fisher’s exact test. McNeman’s test was used to compare sphericity disagreement between different views within the group. The level of significance was defined as p<0.05 for all tests.\textsuperscript{12}

Femoral sphericity had a higher percentage of asphericity in all FAI patients on all radiographic views (p<0.0001). The highest percentage of aspherical heads was seen on frog lateral view (88%). The frog lateral showed the highest sensitivity in alpha angle measurements (65.2\%) on all three views as compared with cross-table lateral views (58\%).\textsuperscript{12}

There were several limitations to this study including the uncontrolled radiographic technique used by the orthopedic radiology technicians. This creates interposition bias which is hard to avoid in a study on imaging. Cross-table lateral views were not taken in IR as noted by previous studies\textsuperscript{12} and there was no prior power analysis to estimate the number of radiographs. The number was noted to still be larger than the previous Notzli et al study.\textsuperscript{1} Another glaring
limitation was the number of control patients (24) as compared to FAI patients (61). FAI patients were older on average and there were more female FAI patients than control patients.\textsuperscript{12}

Research stated that the alpha angle has been seen as the most useful measurement in detecting cam lesion asphericity due to its reliability,\textsuperscript{9} while head-neck offset is considered the least reliable.\textsuperscript{12} The alpha angles recorded (65 degrees for FAI and 44 degrees for control) were similar to the results from Meyer et al\textsuperscript{11} which were 71 degrees for FAI and 50 degrees for control) the study concluded that frog lateral could be used instead of the 45-degree Dunn view or at least as an additional image in initial diagnosis of FAI cam lesions. The study stated it included the pelvis in imaging for a more accurate view of an alpha angle. The study also stated that although the MRI is superior to the frog lateral view, it requires expertise and is not always readily available to patients. It claims that the frog lateral view is adequate to diagnosing abnormalities of the femoral head-neck junction.\textsuperscript{12}

**Domayer et al**

This was a retrospective study\textsuperscript{10} in which a total of 60 hips (49 cases) were obtained with radial MRIs and associated plain film radiographs. The purpose of the study was to see the sensitivity and specificity regarding alpha angle with radial MRI and plain film radiographs in demonstrating a cam lesion. These cases ranged from 2006-2009, with 31 male and 29 female participants. Thirty eight cases were taken with AP and 45-degree Dunn lateral views and 22 were taken in AP and cross-table lateral views along with MRI films. Inclusion criteria included a positive history of FAI. An MRI with either Dunn and AP or cross-table and AP also needed to be drawn within six months of diagnosis of FAI. SCFE’s, Legg-Calve-Perthes disease, and prior femoral neck fractures were part of the exclusion criteria.\textsuperscript{10}
AP views were performed in traditional methods as well as 45-degree Dunn lateral views. Cross-table lateral view was performed with the patient lying supine and contralateral hip flexed to 80 degrees. The symptomatic hip was rotated 15 degrees IR and the x-ray was aimed in a 45 degree-angle at the femoral head. The MRI system was a 1.5T Siemens with an eight channel surface coil and 3D dual flip angle 160 mm field of view. 3D data sets were used to reconstruct the femoral head-neck axis in 30 degree oblique intervals. Two musculoskeletal experts with 15 years of experience in image evaluation reviewed radiographs separately on a PACS station. Matlab was used for all angle measurements. Ten random cases were selected and re-measured by the senior author who was blinded to the original readings. In order to confirm reliability of the readings, the author waited six months to reevaluate the measurements. Additionally, eight weeks after the first readings, 10 random cases were reevaluated by the readers to assess intrareader reliability. \(^\text{10}\)

Alpha angles for all radiographs were performed using the method described by Notzli. \(^\text{1}\) Radial MRI took seven different alpha angles (anterior, anterosuperior, superoanterior, superior, superoposterior, posterosuperior, and posterior) in order to locate the aspect of the femoral head-neck junction most associated with a cam lesion. \(^\text{10}\)

Statistical analysis was carried out using SPSS on a Windows format. Alpha angle, intraobserver, and interobserver reliability were evaluated with ICC analysis for both MRI and plain film radiographs. For baseline, frequency analysis of max alpha angle location and size were carried out. Metrics of 45-degree Dunn lateral and cross-table lateral were compared using a two sided t-test. Pearson’s correlation was used to evaluate the relationships between radial MRI alpha angles on different locations of the femur. Using the max alpha angles from radial

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MRI, a state variable cross-table analysis tested for sensitivity and specificity for detecting alpha angles >55 degrees on both plain films and MRI.\(^\text{10}\)

ICC variability of alpha angle measured .943 for MRI and .945 for radiographs. Interobserver variability was .804 for MRI and .972 for radiographs. Radial MRI showed maximum alpha angles at the anterosuperior aspect of the femoral head-neck junction in more than 53% of the cases of FAI. Alpha angle was >55 degrees in 45/60 cases and max alpha angles ranges from 38-93.7 degrees. Cam deformity was found in 48.3% of the AP views and 58.3% in 45-degree Dunn lateral views. Bivariate correlation of analysis of alpha angles on radiograph and radial MRI found the strongest correlation with 45-degree Dunn Lateral view and anterosuperior aspect of the MRI. Sensitivity for the 45-degree Dunn lateral was 96% with radial MRI and 70% with cross-table lateral. Specificity with 45-degree Dunn lateral was 90% and 100% with cross-table lateral. The ratio of correct positive cases was much higher in the 45-degree Dunn lateral view than cross-table lateral (\(p<0.013\)) using Pearson’s chi square test.\(^\text{10}\)

There were definite limitations noted in the study including the fact that no subjects had both 45-degree Dunn lateral views and cross-table lateral views. It was also stated that the study had no control group to compare with FAI subjects. The study also did not compare the 45-degree Dunn view to the frog lateral view which has been previously researched as superior to cross-table lateral view.\(^\text{11}\) The research also did not explain how the FAI was diagnosed for the selected imaging.\(^\text{10}\)

The study explained how radial MRI remains the gold standard\(^\text{7}\) for alpha angle measurement and it is usually measured best in the anterosuperior border of the femoral head-neck junction. Radiographs in this study were seen as less sensitive (88% overall sensitivity) compared to MRI. Separate evaluation of the 45-degree Dunn lateral and cross table lateral
views showed that the Dunn view provided excellent sensitivity (96.4%) vs (70.6%) for the cross-table view. They finalized that the Dunn view can improve radiographic impingement diagnostics due to where it visualizes the femur. This study also noted its agreement with Meyer et al\textsuperscript{11} in the Dunn view being superior to the frog lateral view, prior to performing this study.\textsuperscript{10}

**DISCUSSION**

Femoroacetabular impingement has grown exponentially over the past ten years and diagnosis and treatment plans continue to evolve. It is important to remember that even with MRI and CT imaging; initial diagnosis requires the use of plain film radiographs.\textsuperscript{1,2} The correct view on radiographs is essential in measuring the proper alpha angle. Not all views of the pelvis are equal when trying to demonstrate a cam lesion. It has been agreed upon in literature that AP and false profile views are an effective way to see acetabular retroversion and pincer lesions;\textsuperscript{1,2} however, it remains disputed which view best demonstrates a cam lesion.\textsuperscript{2,11} There is a need for a consensus guide for primary care and orthopedic clinicians to use as a resource for appropriate lateral imaging.

Three of the four studies acknowledge that 45-degree Dunn lateral is the most specific view for cam demonstration.\textsuperscript{10,11,13} The studies state the Dunn view, with hip flexed to 45-degrees and 20-degrees of abduction, allows for the x-ray beam to have the maximum deviation to view the alpha angle.\textsuperscript{2,10} All four studies used proper methods\textsuperscript{1} in obtaining the alpha angle. They described measurement of the angle between a line from the center of the femoral head through the middle of the femoral neck and a line through a point where the contour of the femoral head-neck junction exceeds the radius of the femoral head.\textsuperscript{1,7,13} All four studies agreed that the most sensitive place to measure the alpha angle in lateral view was the anterosuperior
The debate begins when researching which specific lateral view best captures the junction.

There is a general consensus in all studies that the Dunn view is most sensitive for cam lesion demonstration, however, Clohisy et al\textsuperscript{12} advocates for the additional use of frog leg lateral view. While this frog image may be used, there already exists a view that has been proven to most accurately demonstrate a cam lesion. Why use the frog lateral view when you already have the 45-degree Dunn lateral?

Furthermore Clohisy et al had limitations to their study including a lack of proper comparison of both Dunn and frog lateral views.\textsuperscript{12} Meyer et al\textsuperscript{11} was limited in sample size and a complete pelvis in their Dunn lateral views.\textsuperscript{11} Limitations in Harris et al\textsuperscript{13} and Meyer et al\textsuperscript{11} included the use of cadaveric skeletons with unclear histories, but these finding don’t affect the alpha angle on the femoral-head neck junction. Domayer et al\textsuperscript{10} had the strongest statistical evidence in their comparison to radial MRI studies showing the superiority of 45-degree Dunn lateral view. All studies were limited by the fact that they were retrospective studies; however this is to be expected with surgical research.

While the individual studies provided overall low GRADE scores for evidence quality, it is still possible to ascertain the strength of evidence behind the correlation with alpha angle and the 45-degree Dunn lateral view. The evidence points to the Dunn view as the best plain film radiographic view in demonstrating a cam lesion. Perhaps more can be done to identify specific guidelines for the initial imaging required for FAI. Three of these studies agree that 45-degree Dunn lateral is the most sensitive view in demonstrating the most common location of a cam lesion.\textsuperscript{10,11,13} This is important because patients being seen for their initial FAI visit need to have
the correct films drawn for their diagnosis. The Dunn view appears to be the most accurate view in order to aid in the demonstration.

CONCLUSION

Studies suggest that the 45-degree Dunn lateral view is at least equal to and even superior to other lateral views on plain film radiograph in the initial evaluation of cam lesions associated with FAI. Research is currently debated with regard to other lateral views being equally as efficient. Further research using a large-scale retrospective comparison study should be performed in order to further validate the claim that the Dunn lateral view is superior to all lateral views in the initial demonstration of a cam lesion. While the orthopedic community looks for further evidence, there is no harm in using the 45-degree Dunn lateral view as first line diagnostic imaging for a cam lesion.

Implementing the 45-degree Dunn lateral view as gold standard initial practice in evaluation of FAI will provide physicians with the highest probability in demonstrating a cam lesion. This will allow for fewer radiographs to be taken, less radiation exposure, and more affordable care for patients being treated for FAI.
References


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¹ Lack of a pelvic acetabulum to clinically imitate a true lateral pelvis
² A small sample size
³ Lack of proper comparison of frog lateral and Dunn lateral view