Bibliographic Cite	Literature Type	Evidence level for results	Purpose	Population	Intervention and Outcome Measures	Results/ Recommendations	Review Method Limitiations
Frank JM, Harris JD, Erickson BJ, et al. Prevalence of femoroacetabular impingement imaging findings in asymptomatic volunteers: A systematic review. Arthroscopy. 2015;31(6):1199-1204.	Meta-Analysis; Review	High	The aim of this study was to determine the prevalence of radiographic findings suggestive of femoroacetabular impingement (FAI) in asymptomatic individuals.	2114 asymptomatic hips: We identified 26 studies for inclusion, comprising 2,114 asymptomatic hips (57.2% men; 42.8% women). The mean participant age was 25.3 +/- 1.5 years. The mean alpha angle in asymptomatic hips was 54.1 degree +/- 5.1 degree.	METHODS: A systematic review was performed using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Studies reporting radiographic, computed tomographic, or magnetic resonance imaging (MRI) findings that were suggestive of FAI in asymptomatic volunteers were included. Cam, pincer, and combined pathologic conditions were investigated.	RESULTS: The authors identified 26 studies for inclusion, comprising 2,114 asymptomatic hips (57.2% men; 42.8% women). The mean participant age was 25.3 +/- 1.5 years. The mean alpha angle in asymptomatic hips was 54.1degree +/- 5.1degree. The prevalence of an asymptomatic cam deformity was 37% (range, 7% to 100% between studies)-54.8% in athletes versus 23.1% in the general population. Of the 17 studies that measured alpha angles, 9 used MRI and 9 used radiography (1 study used both). The mean lateral and anterior center edge angles (CEAs) were 31.2degree and 30degree, respectively. The prevalence of asymptomatic hips with pincer deformity was 67% (range 61% to 76% between studies). Pincer deformity was poorly defined (4 studies [15%]; focal anterior overcoverage, acetabular retroversion, abnormal CEA or acetabular index, coxa profunda, acetabular protrusio, ischial spine sign, crossover sign, and posterior wall sign). Only 7 studies reported on labral injury, which was found on MRI without intra-articular contrast in 68.1% of hips.; CONCLUSIONS: FAI morphologic features and labral injuries are common in asymptomatic patients. Clinical decision making should carefully analyze the association of patient history and physical examination with radiographic imaging.; LEVEL OF EVIDENCE: Level IV, systematic review if Level II-IV studies.	Limitations The limitations of a systematic review are based on the limitations of the studies analyzed. The heterogeneity in defining cam and pincer morphologic conditions is a significant source of selection bias. Other sources of selection bias include the heterogeneity in participant age, sex, activity level, and sports played. Detection bias is present in that the radiographic techniques, quality, and adequacy are also highly variable. Assignment of FAI morphologic features was made by both radiography and MRI on different radiographic (anteroposterior and a variety of lateral techniques) and MRI views (both arthrographic and nonarthrographic sagittal, coronal, axial, oblique, and radial series) and with different threshold values to determine "normal" and "abnormal." Additionally, there is no perfect definition of what a "normal" hip radiograph constitutes. Thus, this makes characterization of "abnormal" challenging. Arthroscopic correlation of imaging findings is the gold standard for confirmation of labral injury; however, this was lacking in the included studies.
Haj-Mirzaian A, Eng J, Khorasani R, et al. Use of advanced imaging for radiographically occult hip fracture in elderly patients: A systematic review and meta-analysis. Radiology. 2020; 296(3):521-531.	Systematic review and meta-analysis	High	To estimate the frequency of radiographically occult hip fracture in elderly patients, to define the higher-risk subpopulation, and to determine the diagnostic performance of CT and bone scanning in the detection of occult fractures by using MRI as the reference standard.	Studies were included if patients were clinically suspected to have hip fracture but there was no radiographic evidence of surgical hip fracture (including absence of any definite fracture or only presence of isolated greater trochanter [GT] fracture). The initial search resulted in 3341 articles. Titles and abstracts were screened, and we selected 107 articles for full-text review. Thirty-five studies met inclusion criteria. Twelve studies (median patient age, 77.4 years; age range, 56–81 years) assessed the rate of occult hip fracture in elderly patients with radiographically isolated GT fracture. Twenty-six studies (median patient age, 80.3 years; age range, 67–82 years) evaluated the rate of surgical hip fracture in elderly patients with no radiographically definite hip fracture.	A literature search was performed to identify English language observational studies published from inception to September 27, 2018. The rate of surgical hip fracture was reported in each study in which MRI was used as the reference standard. The pooled rate of occult fracture, diagnostic performance of CT and bone scanning, and strength of evidence (SOE) were assessed.	The frequency of radiographically occult surgical hip fracture was 39% (1110 of 2835 patients; 95% confidence interval [CI]: 35%, 43%) in studies of patients with no definite radiographic fracture and 92% (134 of 157 patients; 95% CI: 83%, 98%) in studies of patients with radiographic evidence of isolated GT fracture (moderate SOE). The frequency of occult fracture was higher in patients aged at least 80 years (44%, 529 of 1184), those with an equivocal radiographic report (58%, 71 of 126), and those with a history of trauma (41%, 977 of 2370) (moderate SOE). CT and bone scanning yielded comparable diagnostic performance in the detection of radiographically occult hip fracture (P = .67), with a sensitivity of 79% and 87%, respectively (low SOE). Conclusion: Elderly patients with acute hip pain and negative or equivocal findings at initial radiography have a high frequency of occult hip fractures. Therefore, the performance of advanced imaging (preferably MRI) may be clinically appropriate in all such patients.	Our study had several limitations. First, there was a possibility of partial verification bias. To address this issue, we performed several subgroup analyses based on the study design, which showed no difference between the corresponding subgroups. Second, moderate statistical heterogeneity was present in most parts of the analyses. By performing subgroup analysis and meta-regression, we could partly explain the impact of age, history of trauma, and radiographic features on the observed high heterogeneity. Third, authors did not have sufficient evidence-based literature data on all clinical variables (eg, bone mineral density, energy, and type of trauma) to define a true low-risk group that could be safely excluded from further assessments. Furthermore, only a few studies stratified the rate of occult fracture according to the results of physical examinations and inability to bear weight. Fourth, authors excluded non–English-language articles, which may have resulted in overlooking several studies. Fifth, a limited number of studies evaluated the diagnostic performance of CT and bone scanning.
Muheremu A, Ma J, Amudong A, et al. Positron emission tomography/computed tomography for osseous and soft tissue sarcomas: A systematic review of the literature and meta-analysis. Molecular and Clinical Oncology. 2017; 7:461-467.	Systematic review and meta-analysis	High	To report on the diagnostic accuracy or treatment effect evaluation of PET/CT in osseous and soft tissue sarcomas.	Of the 1,310 articles screened, 16 were selected for the final analysis. Sixteen trials with a total of 883 patients and 2,214 lesions were included in the present study. A total of 9 studies, including 738 patients with 2,069 lesions, investigated the diagnostic accuracy of PET/CT in osseous and soft tissue sarcomas. A total of 7 studies, including 145 patients, investigated the accuracy of PET/CT in assessing the treatment effect of neoadjuvant therapy on patients with osseous and soft tissue sarcomas.	Two indepent reviewers performed a search of databases. The authors independently assessed the quality of the included studies by the Quality Assessment of Diagnostic Accuracy Studies (QUADAS) tool. Each study was scored as "positive", "negative", or "unclear". In case of disagreement, a third author made the final decision. Studies with < 7 "positive" were considered to be of low methodological quality and high risk of bias. Data in the included trials were extracted by two independent reviewers.	The overall diagnostic accuracy of PET/CT exhibited a sensitivity and specificity of 0.90 (0.86-0.92) and 0.89 (0.85-0.92), respectively, and the effect of neoadjuvant therapy was assessed with a sensitivity and specificity of 0.79 (0.30-0.93) and 0.79 (0.69-0.89), respectively. Thus, it may be concluded from the present study that PET/CT is a reliable imaging method to be applied in the diagnosis and treatment of osseous and soft tissue malignancies.	Although the present study provided evidence on the applicability of PET/CT on the diagnosis and evaluation of response to neoadjuvant therapy for osseous and soft tissue sarcomas using the SUV max value, and the quality of the included studies was relatively high, the overall sample size may be insufficient. Considering that osseous as well as soft tissue sarcomas are malignancies with a low-incidence, multi-center prospective studies with longer follow-up are required to investigate the full potential of PET/CT in the diagnosis and treatment of musculoskeletal tumors.
Reiman MP, Thorborg K, Goode AP, et al. Diagnostic Accuracy of Imaging Modalities and Injection Techniques for the Diagnosis of Femoroacetabular Impingement/Labral Tear: A Systematic Review With Meta-analysis. American Journal of Sports Medicine. 2017;45(11):2665-77.	Systematic Review	Moderate level of evidence	Summarize and evaluate the diagnostic accuracy and clinical utility of various imaging modalities and injection techniques relevant to hip FAI/ALT.	1282 patients in 25 articles examining clinical examination for FAI/ALT were eligible if each met all of the following criteria: (1) included live human subjects with hip pain suspected to be related to hip FAI/ALT, (2) included at least 1 imaging and/or intra-articular injection modality for diagnosis of FAI/LT, (3) used surgery as the gold standard, (4) reported the results in sufficient detail to allow reconstruction of contingency tables to allow calculation of diagnostic accuracy metrics, (5) scored 10 or higher on the Quality Assessment of Diagnostic Accuracy Studies (QUADAS) tool, and (6) were written in English or Danish (due to authors' native speaking language).	A computer-assisted literature search was conducted of MEDLINE, CINAHL, and EMBASE databases using keywords related to diagnostic accuracy of hip joint pathologic changes. The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines were used for the search and reporting phases of the study. Quality assessment of bias and applicability was conducted using the Quality of Diagnostic Accuracy Studies (QUADAS) tool. Random effects models were used to summarize sensitivities (SN), specificities (SP), likelihood ratios (1LR and –LR), diagnostic odds ratios (DOR), and respective confidence intervals (CI).	The search strategy and assessment for risk of bias revealed 25 articles scoring above 10/14 on the items of the QUADAS. Four studies investigated FAI, and the data were not pooled. Twenty articles on ALT qualified for meta-analysis. Pretest probability of ALT in the studies in this review was 81% (72%-88%), while the pretest probability of FAI diagnosis was 74% (95% CI, 51%-91%). The meta-analysis showed that computed tomography arthrography (CTA) demonstrated the strongest overall diagnostic accuracy: pooled SN 0.91 (95% CI, 0.83-0.96); SP 0.89 (95% CI, 0.74-0.97); 1LR 6.28 (95% CI, 2.78- 14.21); –LR 0.11 (95% CI, 0.06-0.21); and DOR 64.38 (95% CI, 19.17-216.21).	Study limitations include the robustness of reporting inclusion-exclusion criteria was highly variable among the studies and very difficult to comprehensively describe in this review, limiting the search strategy to only those articles written in English or Danish language could potentially exclude some relevant studies, using 1 author to extract the primary data points, and lack of comparison of subject inclusion and exclusion across the studies, and assigning only 1 author to extract the data points increases the risk of potential error
Saied AM, Redant C, El-Batouty M, et al. Accuracy of magnetic resonance studies in the detection of chondral and labral lesions in femoroacetabular impingement: systematic review and meta-analysis. BMC Musculoskelet Disord. 2017;18(1):83.	Systematic Review	Moderate level of evidence	The aim of this meta-analysis is to detect the accuracy of conventional magnetic resonance imaging (cMRI), direct magnetic resonance arthrography (dMRA) and indirect magnetic resonance arthrography (iMRA) in the diagnosis of chondral and labral lesions in femoroacetabular impingement (FAI)	21 studies with 828 patients, including studies reporting the diagnostic test accuracy (sensitivity/specificity) of cMRI, dMRA and iMRA for the assessment of chondral and labral lesions in FAI with surgical comparison (open or arthroscopic) as the reference test, were included. Other inclusion criteria are publications must be reported in International Peer-reviewed Journals with English abstract, all studies handling data on chondral and labral lesions in FAI were included even if the paper investigated and presented a wider range of other hip joint pathology, all studies must include cMRI or dMRA or iMRA as diagnostic tests with surgical comparison as the reference test and studies in which sensitivity and specificity are mentioned.	A literature search was finalized on the 17th of May 2016 to collect all studies identifying the accuracy of cMRI, dMRA and iMRA in diagnosing chondral and labral lesions associated with FAI using surgical results (arthroscopic or open) as a reference test. Pooled sensitivity and specificity with 95% confidence intervals using a random-effects meta-analysis for MRI, dMRA and iMRA were calculated also area under receiver operating characteristic (ROC) curve (AUC) was retrieved whenever possible where AUC is equivocal to diagnostic accuracy.	The search yielded 192 publications which were reviewed according inclusion and exclusion criteria then 21 studies fulfilled the eligibility criteria for the qualitative analysis with a total number of 828 cases, lastly 12 studies were included in the quantitative meta-analysis. Meta-analysis showed that as regard labral lesions the pooled sensitivity, specificity and AUC for cMRI were 0.864, 0.833 and 0.88 and for dMRA were 0.91, 0.58 and 0.92. While in chondral lesions the pooled sensitivity, specificity and AUC for cMRI were 0.76, 0.72 and 0.75 and for dMRA were 0.75, 0.79 and 0.83, while for iMRA were sensitivity of 0.722 and specificity of 0.917. The present meta-analysis showed that the diagnostic test accuracy was superior for dMRA when compared with cMRI for detection of labral and chondral lesions. The diagnostic test accuracy was superior for labral lesions when compared with chondral lesions in both cMRI and dMRA. Promising results are obtained concerning iMRA but further studies still needed to fully assess its diagnostic accuracy.	Study limitations include most of studies showed high risk of bias in identification of cohort recruitment. There was some variation in the results for the risk of bias specially for the description of time between MRI and surgery.

Wilson MP, Nobbee D, Murad MH, et al. Diagnostic accuracy of limited MRI protocols for detecting radiographically occult hip fractures: A systematic review and meta-analysis. AJR Am J Roentgenol. 2020; 215(3):559-567.	Systematic review and meta-analysis	Moderate	To evaluate the diagnostic accuracy of limited MRI protocols for detecting radiographically occult proximal femoral fractures.	Original articles with 10 or more patients evaluating limited MRI protocols for the diagnosis of radiographically occult proximal femoral fractures compared with multiparametric MRI with or without clinical outcome as the reference standard were included in the analysis. A total of 938 patients with 247 proximal femoral fractures were included in this review. The mean age of the pooled cohort was 70 years (range, 12–100 years), and 69% (575/838) of the population was female in studies reporting sex. Of the 938 patients, 602 patients with 110 proximal femoral fractures were included in the meta-analysis.	A systematic review of MEDLINE, Embase, Scopus, the Cochrane Library, and the gray literature through November 15, 2019, was performed. Patient, clinical, MRI, and performance parameters were independently acquired by two reviewers. Meta-analysis was performed using a bivariate mixed-effects regression model.	The pooled and weighted summary sensitivity and specificity and the area under the summary ROC curve for limited MRI protocols in detecting radiographically occult hip fractures were 99% (95% CI, 91–100%), 99% (95% CI, 97–100%), and 1 (95% CI, 0.99–1), respectively. The aggregate sensitivity and specificity values for a single-plane T1-weighted sequence only, STIR sequence only, T1-weighted and STIR sequences, and T2-weighted sequence only were as follows: 97% (89/92) and 100% (76/76), 99% (126/127) and 99% (865/873), 100% (118/118) and 99% (867/874), and 86% (51/59) and 97% (137/141), respectively. Sensitivity was 100% (58/58) when images were acquired on 3-T scanners only and 99% (284/288) when interpreted only by certified radiologists. The mean scanning time for the limited MRI protocols was less than 5 minutes. CONCLUSION. Limited MRI protocols can be used as the standard of care in patients with a suspected but radiographically occult hip fracture. A protocol composed of coronal T1-weighted and STIR sequences is 100% sensitive.	Although this systematic review notes a decrease in active scanner time with use of a limited MRI protocol compared with a multiparametric MRI protocol, this review does not specifically compare the difference in diagnostic image quality of individual sequences in a limited MRI protocol versus those in a multiparametric MRI protocol and does not evaluate the entire time required to perform an MRI examination (including transfer time and time between sequence acquisitions) in this patient population.
Yang HL, Liu T, Wang XM, Xu Y, Deng SM. Diagnosis of bone metastases: A meta-anaysis comparing FDG PET, CT, MRI and bone scintigraphy. Eur Radiol. 2011; 21(12):2604-2617.	Meta-analysis	High	The purpose of the study is to perform a meta-analysis to compare the value of FDG PET, CT, MRI and BS for the diagnosis of bone metastases, and then to find out which is the best diagnostic technique for bone metastases.	67 articles, consisting of 145 studies, fulfilled all inclusion criteria. There were a total of 15,221 patients in the studies selected, with ages ranging from 10-91 years old. In 106 studies, the sex distribution was described : 5905 patients were male and 4427 patients were female. The published year ranged from 1997 to 2010.	Two reviewers independently assessed potentially eligible studies and then independently extracted relevant data from each article by using a standardized form (QUADAS quality assessment tool). Data were separately analyzed for PET, CT, MRI and BS. Pooled sensitivity, specificity, DOR and SROC for each technique were calculated. Next, a meta-regression analysis was performed. A subgroup analysis of the technical differences of each technique was also performed.	On a per-patient basis, the pooled sensitivity estimates for PET, CT, MRI and BS were 89.7%, 72.9%, 90.6%, and 86.0%, respectively. PET=MRI>BS>CT. The pooled specificity estimates for PET, CT, MRI and BS were 96.8%, 94.8%, 95.4% and 81.4% respectively. PET=CT=MRI>BS. On a per-lesion basis, the pooled sensitivity estimates for PET, CT, MRI and BS were 86.9%, 77.1%, 90.4%, and 75.1% respectively. PET=MRI>BS>CT. The pooled specificity estimates for PET, CT, MRI and BS were 97.0%, 83.2%, 96.0% and 93.6% respectively. PET>MRI>BS.CT. CONCLUSION: PET and MRI were found to be comparable and both significantly more accurate than CT and BS for the diagnosis of bone metastases.	Publication bias is a potential limitation of any meta-analysis. The authors attempted to examine publication bias by using an evaluation of whether the size of stuides was associated with the results of diagnostic accuracy. Additionally, several limitations are present in any meta-analysis study of a diagnostic test. First, there is no accepted gold standard. Another limitation is the consideration of 2x2 tables for multiple CT and MRI techniques as separate data sets; this was performed to avoid selection bias. A further possible limitation is that a multiple backward stepwise regression analysis was performed with 19 covariates, and the final model was adjusted for significant variables. A final limitation was the diversity of tumor types.