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Original Research Article

Comparison of conventional radiograph with low-dose computed tomography of sacroiliac joints in patients with proven sacroiliitis

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ABSTRACT

Background: Sacroiliitis is central to diagnosing axial spondyloarthritis (axSpA), yet conventional radiography suffers from anatomical superimposition and low sensitivity for early structural change. Low-dose computed tomography (LDCT) provides cross-sectional detail at a radiation dose comparable to plain radiography. Aim was to evaluate LDCT versus conventional sacroiliac (SI) joint radiography in assessing sacroiliitis.
Methods: This prospective, observational, cross-sectional study enrolled 30 consecutive adults with proven sacroiliitis at a tertiary centre. All underwent pelvic radiography (SAPA view) and LDCT of the SI joints (Philips Brilliance iCT 256-slice; 120 kV, 30 mAs; effective dose ~1 mSv). Two blinded radiologists independently scored 60 SI joints using a modified European image-quality system covering technical parameters (joint-margin and soft-tissue delineation, superior/inferior visualisation, absence of superimposition) and pathological parameters (joint-space change, erosions, sclerosis, soft-tissue content). Chi-square/Fisher's exact and unpaired t-tests were used; $p<0.05$ was significant.
Results: Mean age was 33.1±8.7 years; 96.7% were male; axSpA accounted for 90.0% of diagnoses. LDCT was significantly superior to radiography for soft-tissue delineation (98.3% versus 18.3%), superior/inferior joint margins (98.3% versus 55.0%), absence of superimposition (100% versus 36.7%), and iliac-margin erosion detection (86.7% versus 55.0%) (all $p<0.001$). Mean total imaging score was 7.6±1.3 for LDCT versus 4.3±1.8 for radiography ($p<0.001$), with consistent superiority across all subgroups; scores correlated strongly ($r=0.742$, $p<0.001$).
Conclusions: LDCT delivered substantially superior image quality and structural-lesion detection than radiography at a comparable dose and should be integrated into diagnostic algorithms for suspected sacroiliitis, particularly when radiographs are inconclusive.

Keywords: Axial spondyloarthritis, Conventional radiography, Low-dose computed tomography, Sacroiliac joint, Sacroiliitis

INTRODUCTION

Low back ache (LBA) is one of the leading causes of years lived with disability worldwide, with an estimated 619 million people affected in 2020 and a projected rise to 843 million by 2050.[1,2] A substantial proportion of patients with chronic inflammatory LBA harbour underlying sacroiliitis as part of axial spondyloarthritis (axSpA) or related spondyloarthropathies, and sacroiliac (SI) joint pathology accounts for up to one-quarter of all chronic LBA presentations.[3] Accurate and timely imaging of the SI joints is therefore central to the diagnostic workup of inflammatory LBA, as early identification of structural lesions allows earlier institution of disease-modifying therapy and prevents progression to irreversible ankylosis.

Plain radiography remains the most widely used initial imaging modality for the SI joints because of its low cost, wide availability, and modest effective radiation dose of approximately 1 mSv.[3,4] However, conventional

radiography is intrinsically limited by anatomical superimposition of bowel gas, sacral wings and overlying soft tissues, which obscure the SI joint surfaces and reduce both inter-observer reliability and sensitivity for subtle erosive and sclerotic changes.[5,6] Magnetic resonance imaging (MRI) is the established gold standard for detecting active inflammatory bone-marrow oedema in early axSpA, while standard-dose computed tomography (SDCT) is more sensitive than radiography for established structural lesions but exposes patients to approximately 8.7 mSv per study, raising concern about cumulative radiation in young adults.[7,8]

Recent advances in CT technology including iterative reconstruction, automatic dose modulation and lower tube-current protocols have enabled the development of low-dose CT (LDCT) protocols that deliver effective doses comparable to those of plain radiography while retaining the cross-sectional, superimposition-free advantage of CT.[9,10] Cadaver and phantom studies have demonstrated that diagnostically acceptable image quality of the lumbosacral spine and SI joints can be obtained at doses as low as 0.37 mSv with iterative reconstruction, and clinical work in spondyloarthritis cohorts has shown that LDCT improves detection of erosions, sclerosis and bony bridging compared with radiography.[11-14]

Indian literature directly comparing conventional SI joint radiography with LDCT in patients with sacroiliitis remains sparse. The present study was therefore designed to evaluate, in a single tertiary care cohort, the comparative diagnostic value of conventional SI joint radiography and LDCT, focusing on technical imaging parameters, pathological detection rates and overall image-quality scoring, with the goal of informing local imaging protocols for inflammatory LBA.

METHODS

This was a prospective, observational, cross-sectional study conducted in the department of radiodiagnosis and imaging at a tertiary care hospital. Patients were enrolled following clearance from the institutional ethics committee, and recruitment continued until the planned sample size was achieved. Written informed consent was obtained from every participant prior to imaging. Consecutive adults (≥18 years) referred from the rheumatology or medicine outpatient department with clinically suspected or established sacroiliitis and imaging evidence of SI joint involvement were eligible for inclusion. Patients who declined consent, were pregnant, were aged less than 18 years, or were unable to comprehend the consent process were excluded.

The sample size was calculated using the standard formula for estimation of a proportion, $N = (Z_{\alpha/2})^2 \times p \times q / d^2$, with $Z_{\alpha/2}=1.96$ (95% confidence level), p=92.0% (the agreement reported for LDCT by Alshamari et al), q=100 − p and absolute error d =10%.[15] This yielded a minimum sample of 28, which was inflated by 10% for non-response to give a final minimum of 30 patients. Thirty consecutive eligible patients were therefore recruited.

All participants underwent pelvic radiography in the SADA view and LDCT of the SI joints on the same day. Radiography used 75 kV for the anteroposterior and 85 kV for the lateral projection with an average exposure of ≈3.5. LDCT was performed on a Philips Brilliance iCT 256-slice scanner at 120 kV, reference 30 mAs, collimation 40 × 0.6 mm, rotation time 0.5 s, pitch 1.4 and field of view 200 × 200 mm, with convolution filter B4 1f and automatic dose modulation, delivering an effective dose of ≈1 mSv. Axial, coronal and sagittal multiplanar reformations of 2 mm thickness and 2 mm increment were transferred to PACS for review.

Sixty SI joints (30 right and 30 left) were assessed independently by two radiologists blinded to all clinical information, using a modified version of the European guidelines on image quality for computed tomography.[15] Technical parameters comprised sharp delineation of the SI joint margins, sharp delineation of adjacent soft tissues, complete delineation of the superior and inferior joint margins, and absence of superimposed bowel gas or soft tissue. Pathological parameters comprised joint-space reduction, joint-space widening, erosions and sclerosis along both sacral and iliac margins, and the presence of adjacent soft-tissue content. Each criterion was scored from 0 (not fulfilled) to a maximum of 1 (confidently fulfilled) and summed to give a total imaging score out of 11 per joint.

Data were entered into Microsoft Excel and analysed using IBM SPSS Statistics version 26. Categorical variables were summarised as frequencies and percentages, and continuous variables as mean±standard deviation. Categorical comparisons between LDCT and radiography were performed using the chi-square test or Fisher's exact test as appropriate; continuous variables were compared using the unpaired t-test. Pearson's coefficient was used for correlation analyses. A p value <0.05 was considered statistically significant at the 95% confidence level.

RESULTS

Thirty patients (60 SI joints) were included. The mean age was 33.1±8.7 years (range 18-56), with the majority of patients in the third and early fourth decades- 11 (36.7%) were aged 31-35 years, 8 (26.7%) were 26-30 years, and 5 (16.7%) were 36-40 years. The cohort was strongly male-predominant (29 men, 96.7%; one woman, 3.3%), consistent with the demographic pattern of axial spondyloarthritis at this centre. Axial spondyloarthritis was the working diagnosis in 27 patients (90.0%), bilateral sacroiliitis with HLA-B27 positivity in 2 patients (6.7%) and bilateral sacroiliitis without HLA typing in 1 (3.3%). The mean duration of low back ache was 2.1±2.8 years; 9 patients (30.0%) had symptoms for ≤6 months, 8 (26.7%) for 6-12 months, 6 (20.0%) for 1-2 years, 5 (16.7%) for 2-3 years and 2 (6.7%) for more than 3 years (Table 1).

Table 1: Baseline demographic and clinical characteristics of the study population (n=30).

Parameters	Values (%)
Total participants	30
Sacroiliac joints analysed	60 (30 right, 30 left)
Mean age±SD (years)	33.1±8.7
Age range (years)	18-56
Male	29 (96.7)
Female	1 (3.3)
Axial spondyloarthritis	27 (90.0)
Bilateral sacroiliitis, HLA-B27 positive	2 (6.7)
Bilateral sacroiliitis (HLA not tested)	1 (3.3)
Mean duration of LBA±SD (years)	2.1±2.8
Duration ≤1 year	17 (56.7)
Duration 1-3 years	11 (36.7)
Duration >3 years	2 (6.7)

LBA- low back ache; SD- standard deviation.

Low-dose CT was significantly superior to conventional radiography across most technical image-quality criteria. Sharp delineation of the SI joint margins was achieved in 93.3-96.7% of joints on LDCT compared with 90.0-93.3% on radiography, a numerical but not statistically significant difference (p=0.705). However, sharp delineation of adjacent soft tissues was achieved in essentially all joints on LDCT (right 100%, left 96.7%) versus only 16.7-20.0% on radiography (p<0.001)- a difference of approximately 80 percentage points. Complete delineation of the superior and inferior aspects of the SI joints was likewise markedly superior with LDCT (right 100%, left 96.7%) compared with radiography (right 53.3%, left 56.7%; p<0.001). Absence of superimposed bowel gas or soft tissue was perfect (100%) on every LDCT examination but achieved on only 36.7% of radiographs (p<0.001), reflecting the fundamental limitation of projectional imaging in the pelvis (Table 2).

LDCT also showed higher detection rates than radiography for the principal structural lesions of sacroiliitis. Erosion along the iliac margin- a key early structural change in axial spondyloarthritis- was detected in 86.7% of joints on LDCT versus 55.0% on radiography (p<0.001). Erosions along the sacral margin, sclerosis along both sacral and iliac margins, and joint-space reduction or widening were all detected more frequently on LDCT, although the differences did not reach statistical significance. Adjacent soft-tissue content was identified in an identical 6.7% of joints by both modalities (Table 3).

Table 2: Comparison of technical image-quality parameters between LDCT and conventional radiography (60 sacroiliac joints).

Technical parameters	LDCT N (%)	Radiograph N (%)	P value
Sharp delineation of SI joint margins	57/60 (95.0)	55/60 (91.7)	0.705
Sharp delineation of adjacent soft tissues	59/60 (98.3)	11/60 (18.3)	<0.001
Superior/inferior aspects well delineated	59/60 (98.3)	33/60 (55.0)	<0.001
Absence of superimposed contents	60/60 (100)	22/60 (36.7)	<0.001

Values pooled across right and left sides (60 joints). Bold red values denote statistical significance at p<0.05 (chi-square/ Fisher's exact test). LDCT, low-dose computed tomography; SI, sacroiliac.

Table 3: Detection of pathological findings on LDCT versus conventional radiography (60 sacroiliac joints).

Pathological findings	LDCT N (%)	Radiograph N (%)	Difference (pp)	P value
Joint-space reduction	29 (48.3)	23 (38.3)	+10.0	0.523
Joint-space widening	3 (5.0)	7 (11.7)	−6.7	0.157
Erosion along sacral margin	39 (65.0)	29 (48.3)	+16.7	0.176
Erosion along iliac margin	52 (86.7)	33 (55.0)	+31.7	<0.001
Sclerosis along sacral margin	39 (65.0)	32 (53.3)	+11.7	0.371
Sclerosis along iliac margin	55 (91.7)	48 (80.0)	+11.7	0.229
Soft-tissue content adjacent to SI joints	4 (6.7)	4 (6.7)	0.0	1.000

Values pooled across right and left sides (60 joints). "Difference (pp)" denotes percentage-point difference (LDCT minus radiograph). Bold red values denote statistical significance at p<0.05 (chi-square/Fisher's exact test).

The composite image-quality score (maximum 11) was substantially and significantly higher with LDCT than with radiography. The mean total score was 7.6±1.3 for LDCT and 4.3±1.8 for radiography (p<0.001), corresponding to 69.1% versus 39.1% of the maximum attainable score- an overall improvement of 30 percentage points. The advantage of LDCT was even more pronounced for technical parameters (4.0/4 versus 1.4/4, a 65 percentage-point gain) and was preserved, although smaller, for pathological parameters (3.6/7 versus 2.9/7, a 10 percentage-point gain). Inter-side consistency (the proportion of paired right/left joints with identical scoring)

was 98.3% for LDCT and 91.7% for radiography (Table 4).

The superiority of LDCT over radiography was preserved across age and disease-duration subgroups. In patients aged 18-30 years (n=12) the mean LDCT score was 7.4±1.3 versus 4.1±1.6 on radiography (difference 3.3; p<0.001); in those aged 31-40 years (n=16) the scores were 7.7±1.1 versus 4.4±1.9 (difference 3.3; p<0.001); and in the two patients aged >40 years the difference was 3.2 points, although this did not reach significance owing to the very small subgroup size (p=0.180). The LDCT advantage was actually largest in patients with the shortest symptom duration (≤1 year, n=17), where mean scores were 7.3±1.4 for LDCT and 3.8±1.7 for radiography (difference 3.5), suggesting that LDCT offers its greatest incremental yield in the very patients in whom radiography is least sensitive. The duration of low back ache correlated weakly but significantly with both LDCT (r=0.287) and radiograph (r=0.312) scores, with the latter relationship being statistically significant (p=0.041). Importantly, LDCT and radiograph scores correlated strongly with one another (r=0.742, p<0.001), indicating that both modalities detect a common underlying pathology, with LDCT simply doing so more sensitively.

Table 4: Aggregate scoring and diagnostic accuracy metrics for LDCT versus conventional radiography.

Metrices	LDCT	Radiograph	Difference / improvement
Mean total score (max 11) ±SD	7.6±1.3	4.3±1.8	p<0.001
Median total score	8.0	4.0–4.5	—
Score range	4-9	1–7	—
Percentage of maximum score	69.1	39.1	+30.0 pp
Technical-parameter score (max 4) (%)	4.0 (100)	1.4 (35.0)	+65.0 pp
Pathological-parameter score (max 7) (%)	3.6 (51.4)	2.9 (41.4)	+10.0 pp
Inter-side consistency	98.3%	91.7%	+6.6 pp
Sensitivity ratio- iliac-margin erosion	—	—	1.58
Sensitivity ratio- soft-tissue delineation	—	—	5.36
Sensitivity ratio- superior/inferior delineation	—	—	1.79

Sensitivity ratio = LDCT detection rate ÷ radiograph detection rate. pp, percentage points. Bold red value denotes statistical significance at p < 0.05 (unpaired t-test).

DISCUSSION

The present prospective comparison of low-dose CT and conventional radiography of the sacroiliac joints in 30 patients with sacroiliitis demonstrated a clear and consistent advantage of LDCT across both technical and pathological imaging parameters, at an effective radiation dose comparable to plain radiography. The overall image-quality score was approximately 80% higher with LDCT (7.6 versus 4.3 out of 11; p<0.001), and the advantage was preserved across age and disease-duration subgroups.

The cohort showed a striking male predominance (96.7%) and a young mean age (33.1 years), with axial spondyloarthritis accounting for 90% of working diagnoses- consistent with the established epidemiology of axSpA in young adults.[16] The relatively short mean symptom duration (2.1 years) and the predominance of patients with symptoms of ≤1 year (56.7%) provided a meaningful opportunity to assess imaging performance in the early-disease window, where radiography is known to be least sensitive.[16,17]

The most decisive advantage of LDCT was in the technical parameters that have long been recognised as the Achilles' heel of conventional radiography: depiction of adjacent soft tissues (98.3% versus 18.3%; p<0.001), complete delineation of the superior and inferior joint margins (98.3% versus 55.0%; p<0.001) and absence of overlying superimposed contents (100% versus 36.7%; p<0.001). These findings are concordant with the lumbar-spine LDCT data of Alshamari et al, who reported odds ratios of 2.9 (95% CI 2.1-4.0) for soft-tissue reproduction and 188 (95% CI 66–539) for absence of superimposed bowel contents in favour of LDCT, and with the phantom and cadaver work of Warncke et al and Alshamari et al, confirming that the cross-sectional advantage of CT is preserved at very low effective doses with iterative reconstruction and automatic dose modulation.[11,15,18]

The pathological findings showed the same directional pattern: LDCT detected more erosions and more sclerosis on both sacral and iliac margins but reached statistical significance only for iliac-margin erosions (86.7% versus 55.0%; p<0.001). The iliac surface is the typical location of the earliest erosive change in axSpA, and the 31.7 percentage-point absolute gain with LDCT therefore translates directly into earlier and more confident identification of structural disease under the modified New York and ASAS imaging criteria.[17] Studies by Weber et al, Klauser et al, Baraliakos et al.[20] and Lambert et al.[21] have likewise shown that LDCT outperforms radiography for erosion, sclerosis and joint-space changes in axSpA, with

reliability and validity comparable to MRI for structural lesions.[12-14,19-22]

The lack of statistical significance for sacral-margin erosions, sclerosis on either margin, or joint-space changes almost certainly reflect the modest sample size rather than true equivalence. All sensitivity ratios in the pooled data (1.34 for sacral-margin erosions, 1.22 for sacral-margin sclerosis, 1.26 for joint-space reduction) favoured LDCT, and a larger study would likely demonstrate statistical significance for these findings as well. The 5.36-fold sensitivity advantage of LDCT for soft-tissue delineation and the 1.79-fold advantage for superior/inferior margin visualisation translate into immediate, clinically actionable gains.

The duration-stratified analysis is particularly relevant for clinical practice. The largest absolute score advantage of LDCT (3.5 points) was observed in patients with symptoms of ≤1 year, in whom radiography is most likely to be falsely negative and in whom early diagnosis has the greatest impact on long-term outcome.[16] This finding directly supports the integration of LDCT into the imaging algorithm of patients with suspected sacroiliitis whose radiographs are non-diagnostic, as also advocated by Weber et al and Maksymowych and Lambert.[14,23] The strong correlation between LDCT and radiograph scores ($r=0.742$; $p<0.001$) confirms that the two modalities are detecting the same underlying pathology, with LDCT acting as a more sensitive readout of identical structural change.

From a radiation-safety perspective, the LDCT protocol delivered an effective dose of approximately 1 mSv, comparable to a SAPA-view pelvic radiograph and roughly eight to nine times lower than standard-dose lumbar spine CT.[8,11] This is well within accepted thresholds for diagnostic imaging in young adults and is consistent with published low-dose SI joint protocols achieving 0.37-1.5 mSv with preserved diagnostic accuracy.[11,12,21] The favourable risk-benefit ratio is particularly relevant in this young, predominantly male cohort, where cumulative radiation exposure is a legitimate concern. Limitations include the modest sample size (n=30), single-centre design, strong male predominance (which limits generalisability to women), and cross-sectional design (which precludes assessment of longitudinal change). The small numbers in the >40-year age group and >3-year duration subgroups limit subgroup inference. The study did not include MRI as a comparator, although MRI remains the gold standard for active inflammation.[24] Strengths include direct intra-patient comparison of two modalities, blinded scoring by two independent radiologists, and quantitative statistical comparison.

CONCLUSION

Low-dose CT of the sacroiliac joints provided substantially superior technical image quality and detection of structural lesions compared with conventional pelvic radiography in patients with proven sacroiliitis, at a comparable effective radiation dose. The advantage of LDCT was greatest for soft-tissue delineation, complete depiction of joint margins, freedom from superimposition, and detection of iliac-margin erosions, and was preserved across all age and disease-duration subgroups. The largest absolute incremental gain was observed in patients with early disease (symptom duration ≤1 year), the very population in whom timely diagnosis most influences long-term outcome. Low-dose CT should therefore be incorporated into routine imaging algorithms for suspected sacroiliitis, particularly when conventional radiographs are equivocal or non-diagnostic. Larger, multicentre studies including women and patients across the entire spectrum of axial spondyloarthritis are recommended to confirm and extend these findings.

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