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FULL PAPER

Interrater reliability and radiation dosage of oblique coronal computed tomography

¹SHENG-GUANG LI, Master's degree, ²XIANGYUAN LIU, MD, ³HUIQIONG ZHOU, MD and ³QING ZHANG, Master's degree

¹Department of Rheumatology and Immunology, Peking University International Hospital, Life Science Park of Zhong Guancun, Beijing, China

²Department of Rheumatology and Immunology, Peking University Third Hospital, Beijing, China

³Department of Rheumatology, The First Affiliated Hospital of Chinese PLA General Hospital, Beijing, China

Address correspondence to: Dr Sheng-Guang Li
E-mail: lishengguang@vip.sina.com

Objective: Sacroiliitis, a prerequisite to the diagnosis of ankylosing spondylitis, can be ascertained by CT when MRI is not available. Oblique coronal CT is an increasingly popular approach when examining sacroiliitis. The goal of this study was to understand how oblique coronal CT compared with axial CT scanning in terms of raters' concordance when diagnosing sacroiliitis.

Methods: 52 subjects < 45 years of age at onset of their chronic lower back pain were sequentially scanned by X-ray, axial CT and oblique coronal CT. The acquired images were graded by two experienced, double-blinded physicians.

Results: Sacroiliitis in the oblique coronal view was sensitive enough for grading disease severity and/or detecting improvement. Interrater reliability for CT (axial + oblique coronal) was higher than X-ray. The diagnosis based upon oblique coronal CT was consistent, while the radiation dose delivered to the gonads was significantly reduced, compared with axial CT.

Conclusion: When MRI is not available, oblique coronal CT should replace axial CT when diagnosing sacroiliitis.

Advances in knowledge: When evaluating sacroiliitis, oblique coronal CT is as accurate as conventional axial CT, yet more advantageous owing to reduced radiation dosage.

INTRODUCTION

Ankylosing spondylitis (AS) primarily affects young adults of reproductive age.¹ A prerequisite to the diagnosis of AS is the presence of sacroiliitis,^{2,3} which can be confirmed by CT.⁴ Although MRI is the preferred method for the diagnosis of sacroiliitis, CT can be a useful approach when MRI is not available. As compared with X-ray, CT is more sensitive and produces better interrater concordance.⁵⁻⁷ When detecting bony erosion and joint space narrowing, CT surpasses MRI.⁸ In addition, CT can reveal evidence of improvement in sacroiliitis.^{3,9} Since CT is considered the "gold standard" for identifying bony erosion in sacroiliitis,¹⁰ research into the diagnostic application of CT to sacroiliitis is of clinical significance.

The commonly used axial position for CT is not ideal owing to the large radiation dose delivered to the gonads (especially the female gonads, since the male gonads can be protected, to some extent, by a lead pouch).¹¹ When examining for sacroiliitis, oblique coronal CT may be more advantageous than axial CT since scanning the sacroiliac joint with the gantry tilted 25° cranially (during oblique coronal CT) delivers less

radiation.¹¹ However, to date, no study has investigated the differences in accuracy or radiation dosage acquired between these two positions when diagnosing sacroiliitis.¹¹

Rater consistency is an important index of reliability when performing CT.^{5,12} Although oblique coronal CT is an increasingly acceptable approach when evaluating sacroiliitis, it has not been compared with axial CT regarding raters' concordance. Such information would add to our current understanding of the potential advantages of oblique coronal CT in this application. The aim of the present study was to compare axial and oblique coronal CT in terms of: (1) the dosage of radiation delivered and (2) the diagnostic consistency when examining the sacroiliac joint as assessed by interrater reliability.

METHODS AND MATERIALS

Subjects

This study was performed in compliance with the regulations of the Institutional Review Board of the Chinese PLA general hospital. All patients gave their written informed consent prior to participation in the study.

52 subjects (26 males and 26 females < 45 years of age at onset of their chronic low back pain) with symptoms suggestive of axial or peripheral spondyloarthritis (SPA) were selected for this study. Pregnant females and those with a history of tumour were excluded.

Diagnostic criteria

The diagnosis of axial SPA was based on the Assessment of Spondyloarthritis International Society classification criteria.^{13,14} The diagnosis of AS was based on the 1984 modified New York classification criteria.² While the 1984 AS criteria is primarily used to assess X-ray results, it is also useful for grading CT results, since there is no current standard for grading clinical CT data. These criteria were originally used to interpret the radiographic signs of AS, but were extended for use in CT scoring. SPA patients lacking affirmative radiographic signs of AS on X-ray, but who had CT evidence of AS, were classified as non-radiographic axial SPA.

Image acquisition

Each patient was first screened by X-ray in the prone position. Anteroposterior projection radiography was performed on the pelvic region. Each patient underwent axial and oblique coronal CT imaging using the same CT scanner (Siemens SOMATOM Emotion 16, Wuxi, China).

During axial CT, the patient was placed in the prone position. Scanning covered the entire sacroiliac joint from top to bottom. The slices were as parallel as possible to the long axis of the sacrum, and perpendicular to the axial skeleton. During oblique coronal CT, the slices were angled by 20–30° to remain as parallel to the anterior border of the sacrum as possible so as to cover the entire sacroiliac joint. Both CT scans used the following parameters: slice thickness of 3.0 mm, voltage of 120 kVp, current of 130 mA and a matrix size of 512 × 512. Radiation doses delivered by both axial and oblique coronal CT were recorded and compared.

Radiation risk evaluation

Radiation dosage was expressed as dose length product (DLP), a direct measure of the overall radiation dose delivered during the CT scan. DLP was determined by multiplying the weighted CT

dose index volume by the scan length, in units of mGy-cm. DLP along with CT dose index volume were directly displayed on the CT model used in this study. The radiation risk assessment was based on the delivered radiation dose, not the absorbed dose, since the calculation of the latter required further consideration of the size and shape of each individual patient.

Image interpretation

The acquired images were archived by a designated manager, who had no role in image interpretation. X-ray or CT image interpretation was based upon the 1984 modified New York classification criteria¹ and related references^{14–19} which divide sacroiliitis into five radiographic grades: 0—normal; 1—possible but unclear alterations; 2—minimal erosions and sclerosis, yet without joint space alterations; 3—apparent erosions and sclerosis, with joint space narrowing or widening and 4—ankylosis (Figure 1).

The signs of sacroiliitis used in the radiographic evaluation included joint space narrowing, subchondral sclerosis, erosions and ankylosis. Joint space narrowing was characterized by a joint space <2.0 mm.²⁰ Determination of subchondral sclerosis was based on the presence of areas of increased bone density. Bone erosions were interpreted as fine cortical defects on the synovial portion of the joint. The last two features can be seen on both sides of the joint.

In the present study, positive sacroiliitis was defined as bilateral sacroiliitis that was graded as 2 or higher, or a unilateral sacroiliitis, graded as 3 or higher. Otherwise, cases were rated as negative.

All images were reviewed and analysed for radiologic signs of sacroiliitis by two rheumatologists with more than 20 years of experience who were blinded to the clinical data and reports. This study focused on the assessment of interrater reliability of the unilateral sacroiliitis data.

Before image interpretation, the physician raters were trained using previous CT and plain radiographs from another 20 patients with SPA as compared with 10 patients without SPA (2 with infection of the sacroiliac joints, 2 with osteitis condensans, 1 with diffuse idiopathic skeletal hyperostosis

Figure 1. CT scans of the sacroiliac joints. The left and right sides are reversed on the figures. (a) Oblique coronal CT and (b) axial CT in the same patient.

Figure 2. Slice positions when performing axial and oblique coronal CT of the sacroiliac joint. The lines indicate the positions of the even slices. Axial CT covers a larger area, including the gonads, while oblique coronal CT encompasses fewer slices and avoids the ovary. Oblique coronal CT delivers a much lower radiation dose than axial CT.

and 5 healthy volunteers). The readers had extensive discussions on the training materials regarding diagnostic criteria and differential diagnosis. Intrareader reliability was assessed during training. The Cohen's κ -values for both readers were >0.6 for interpreting axial CT, oblique coronal CT and X-ray. During image rating, patients' plain films were first distributed randomly to the raters, then the axial CT scans and finally the oblique coronal CT scans were distributed. The raters were also allowed to access the images using the computer to adjust the contrast and brightness for optimal diagnosis. The raters were given 5-min breaks after reading each set of images. When the reading was finished, the images were collected and sorted along with the clinical data by the manager, and given to the raters as a whole for the clinical diagnosis on a one by one basis.

Statistical analysis

To understand interrater/rating consistency, the unweighted κ -value was calculated and compared.⁴ Cohen's κ measures the consensus between two raters/ratings. κ was assessed using the following equation:

$$\kappa = (P_o - P_c) / (1 - P_c)$$

where P_o represents the relative observed agreement between the raters/ratings while P_c is the hypothetical probability of chance agreement.

According to Landis and Koch¹⁹, κ -values are classified as poor (<0), slight (0–0.2), fair (0.21–0.40), moderate (0.41–0.60), substantial (0.61–0.80) and almost perfect (>0.8).

The paired t -test compared DLPs from oblique coronal CT to those from axial CT. A p -value of 0.05 was considered statistically significant.

RESULTS

Demographic data

A total of 26 male and 26 female patients suspected of SPA were included in the study. All included patients had chronic back pain of unknown origin lasting for more than 3 months that began before 45 years of age, with or without peripheral articular symptoms.

Slice positions and radiation dose during axial and oblique coronal CT

(Figure 2) shows the slice positions used during axial and oblique coronal CT scans of the sacroiliac joints of an 35-year-old female patient. She had experienced joint pain in the left knee for more than a year, accompanied by intermittent low back pain. The lines indicate the positions of the even slices. A total of 32 slices were obtained on axial CT. Both sacroiliac joints and the female gonads (*i.e.* the ovary in this figure) were exposed to radiation. By contrast, on oblique coronal CT, 16 slices were needed to cover the area of interest. The radiation dose delivered by oblique coronal CT was significantly reduced as compared with the axial CT, as shown in the figure.

DLP was 115.06 ± 22.74 mGy-cm on axial CT and 61.81 ± 13.47 mGy-cm on oblique CT. The DLP on oblique coronal CT was significantly lower compared with that of axial CT ($p < 0.001$). In females, the precise positioning and gantry angle

Figure 3. CT scans from four different patients. (a) Mild asymmetric sclerosis and suspicious bony erosions on the iliac side of the right sacroiliac joint (Grade 1); (b) definite unilateral sacroiliitis (Grade 2); (c) definite and advanced bilateral sacroiliitis (Grade 3) and (d) bilateral advanced sacroiliitis with complete ankylosis (Grade 4).

of oblique coronal scans prevented the ovaries from being exposed directly to radiation. In males, the gonads were closer to the radiation when performing axial CT as compared with oblique coronal CT.

Oblique coronal CT images during examination for sacroiliitis

Figure 1a,b shows the axial and oblique coronal CT scans obtained from the same patient. More proportions of the sacroiliac joint and more bony erosions are seen in the oblique coronal plane as compared with the axial plane on CT.

Figure 3a–d demonstrates several cases of sacroiliitis of differing severity on axial CT. Figure 3a shows mild asymmetric sclerosis and suspicious bony erosions on the iliac side of the right sacroiliac joint. The patient was a 23-year-old male who had experienced pain in the right hip for 4 months. Figure 3b shows definite unilateral sacroiliitis, with minor, yet definite, bony erosions and dense inflammatory sclerosis surrounding the right sacroiliac joint. The patient was a 19-year-old female with low back pain

for approximately a year. Figure 3c demonstrates definite and advanced bilateral sacroiliitis, with obvious erosion and inflammation in the two joints. The patient was a 21-year-old male with low back pain for 4 years. Figure 3d shows complete ankylosis of both sacroiliac joints. The patient was a 34-year-old female who had suffered lumbosacral pain for 20 years. The results imply that CT is more suitable for identifying advanced sacroiliitis, but not inflammation.

Interrater reliability using X-ray, axial CT and oblique coronal CT

As shown in Table 1, the interrater reliability of the diagnosis using X-ray, axial CT and oblique coronal CT was 0.547, 0.807 and 0.726, respectively, for bilateral sacroiliitis and 0.587, 0.691 and 0.674, respectively, for unilateral sacroiliitis. The κ -values support CT as a more reliable tool than X-ray for the diagnosis of sacroiliitis. As shown in the table, in terms of specificity, false

Table 1. Interrater reliability using X-ray, axial CT and oblique coronal CT

		κ	95% Confidence interval	Sensitivity	Specificity	False-positive rate	False-negative rate
Unilateral sacroiliitis	X-ray	0.587 ± 0.082	0.426–0.747	0.889	0.683	0.317	0.111
	Axial CT	0.691 ± 0.071	0.552–0.830	0.839	0.839	0.839	0.839
	Oblique coronal CT	0.674 ± 0.072	0.533–0.815	0.800	0.878	0.122	0.200
Bilateral sacroiliitis	X-ray	0.547 ± 0.110	0.332–0.761	0.917	0.643	0.357	0.357
	Axial CT	0.807 ± 0.082	0.647–0.968	0.880	0.926	0.074	0.120
	Oblique coronal CT	0.726 ± 0.096	0.537–0.915	0.864	0.867	0.133	0.136

Table 2. Interrater reliability among different assessment tools

	κ	95% Confidence interval	Sensitivity	Specificity	False-positive rate	False-negative rate
Clinical diagnosis vs X-ray	0.392 $\pm$ 0.087	0.221–0.563	0.607	0.792	0.208	0.393
Clinical diagnosis vs both CT	0.874 $\pm$ 0.034	0.808–0.940	0.887	0.982	0.018	0.113
Axial CT vs oblique coronal CT	0.883 $\pm$ 0.066	0.754–1.000	0.955	0.933	0.067	0.067

positivity and false negativity, both axial CT and oblique coronal CT performed better than X-ray.

Interrater reliability among X-ray, CT and clinical diagnosis

As indicated in Table 2, the rater reliability between X-ray and clinical diagnosis was 0.392. The rater reliability between CT (both axial and oblique coronal combined) was 0.874. The κ -value between axial and coronal CT (from all ratings) was 0.883, which indicates that oblique coronal CT was highly consistent with that of axial CT.

DISCUSSION

Besides MRI, CT is also an acceptable and sensitive approach for detecting sacroiliitis.⁴ Since the joint facets of the sacroiliac joints are C-shaped and inclined,⁴ oblique coronal positioning has been proposed as an alternative to axial CT. Studies have shown that, oblique coronal CT may facilitate diagnosis, when optimized based on viewing angle, by providing better visualization of erosion, joint space alteration and bone density changes.

Our results showed that the interrater reliability when using CT (axial and oblique coronal combined) was higher than that of X-ray and that the diagnosis based upon oblique coronal CT was highly consistent with that of axial CT. These results support the use of oblique coronal CT in place of axial CT based on several advantages including: (1) better views of the joints; (2) reduced radiation dosage to the gonads and (3) high reader reliability. Based upon oblique coronal CT, subtle pathological signs suggestive of erosive inflammatory reactions within the sacroiliac joints were detectable. Even after the diseased condition is treated, repeat CT examination can be used to confirm recovery of the joints.⁹

A previous study had indicated that the interrater reliability using CT for evaluation of sacroiliitis was 0.672, which was higher than plain radiographs.⁶ This finding is consistent with our κ value of 0.691. Our study extended this assessment, and showed good diagnostic agreement between axial and oblique coronal CT. Thus, oblique coronal CT can offer better views of the sacroiliac joints with reduced radiation and an equally reliable diagnosis compared with axial CT. This evidence is essential for promoting the idea that oblique coronal CT may replace axial CT (which still is widely used in many countries including China) for the diagnosis of sacroiliitis.

The finding that interrater reliability and specificity was lower in reading X-ray images compared with CT scans has been previously reported.⁶ This finding is still noteworthy because conventional X-ray remains the most utilized tool in clinical practice, but

X-ray images fail to confer consistent rating results between physicians regarding diagnosis.²¹ The reduced reliability in rating X-ray images is often caused by overlapping structures which severely affect the rater's ability to determine subtle abnormalities in the sacroiliac joints during the early stages of disease.

Reduced radiation dosage is essential when performing CT, especially when the female gonads are exposed during evaluation.^{22,23} Before multiplanar CT was made available, efforts were made to reduce radiation dose when imaging sacroiliitis. The early techniques involved the choice of the most appropriate levels for sectioning, thus, significantly reducing examination time and radiation exposure.²⁴ The concept of acquiring oblique CT scans of the sacroiliac joints was proposed by Lawson et al²⁵ and Carrera.²⁶ The technique required the gantry to be angled so that the scan plane was as parallel as possible to the long axis of the upper sacrum. This technique theoretically resulted in a reduced effective radiation dose in females as well as prevented direct exposure to the ovaries. To our knowledge, only data from outdated CT scanners have been reported regarding the radiation doses delivered when diagnosing sacroiliitis. Information from modern CT scanners remains unknown.²⁷ We found that 115 mGy-cm were delivered when using axial CT compared with 62 mGy-cm when oblique coronal CT was used. Our findings indicate that the already reduced dose from modern multidetector CT can be further reduced by an optimized slice position.

Limitations

Our study had several limitations. Almost half the patients had a disease duration of less than 10.5 months which made it difficult to determine whether oblique coronal CT or axial CT were sensitive enough to detect structural changes such as erosions and joint space narrowing. Moreover, the CT model used in the present study is considered out of date. More modern CT scanners deliver even less radiation dose than those used in the present study. But, our focus was to show that oblique coronal slicing was better than axial slicing regardless of the CT model used for the examination.

CONCLUSION

In summary, we found that oblique coronal CT imaging can visualize the subtle radiologic signature of sacroiliitis while delivering less radiation dose to the female gonads while still providing a reliable diagnosis. These advantages may justify the use of oblique coronal CT as an alternative to axial CT for the assessment of sacroiliitis.

REFERENCES

- Feldtkeller E, Khan MA, van der Heijde D, van der Linden S, Braun J. Age at disease onset and diagnosis delay in HLA-B27 negative vs. positive patients with ankylosing spondylitis. *Rheumatol Int* 2003; **23**: 61–6. doi: <https://doi.org/10.1007/s00296-002-0237-4>
- Mau W, Zeidler H, Mau R, Majewski A, Freyschmidt J, Stangel W, et al. Clinical features and prognosis of patients with possible ankylosing spondylitis. Results of a 10-year followup. *J Rheumatol* 1988; **15**: 1109–14.
- Rudwaleit M, van der Heijde D, Landewé R, Listing J, Akkoc N, Brandt J, et al. The development of assessment of SpondyloArthritis international Society classification criteria for axial spondyloarthritis (Part II): validation and final selection. *Ann Rheum Dis* 2009; **68**: 777–83. doi: <https://doi.org/10.1136/ard.2009.108233>
- Devauchelle-Pensec V, D'Agostino MA, Marion J, Lapiere M, Jousse-Joulin S, Colin D, et al. . Computed tomography scanning facilitates the diagnosis of sacroiliitis in patients with suspected spondylarthritis: results of a prospective multicenter French cohort study. *Arthritis Rheum* 2012; **64**: 1412–9. doi: <https://doi.org/10.1002/art.33466>
- Geijer M, Göthlin GG, Göthlin JH. The clinical utility of computed tomography compared to conventional radiography in diagnosing sacroiliitis. A retrospective study on 910 patients and literature review. *J Rheumatol* 2007; **34**: 1561–5.
- Geijer M, Göthlin GG, Göthlin JH. Observer variation in computed tomography of the sacroiliac joints: a retrospective analysis of 1383 cases. *Acta Radiol* 2007; **48**: 665–71. doi: <https://doi.org/10.1080/02841850701342146>
- Lacout A, Rousselin B, Pelage JP. CT and MRI of spine and sacroiliac involvement in spondyloarthropathy. *AJR Am J Roentgenol* 2008; **191**: 1016–23. doi: <https://doi.org/10.2214/AJR.07.3446>
- Rémy M, Bouillet P, Bertin P, Leblanche AF, Bonnet C, Pascaud JL, et al. Evaluation of magnetic resonance imaging for the detection of sacroiliitis in patients with early seronegative spondylarthropathy. *Rev Rhum Engl Ed* 1996; **63**: 577–83.
- Li SG. Clinical images: healing of sacroiliitis with leflunomide and sulfasalazine treatment. *Arthritis Rheum* 2008; **58**: 1527. doi: <https://doi.org/10.1002/art.23465>
- Elgafy H, Semaan HB, Ebraheim NA, Coombs RJ. Computed tomography findings in patients with sacroiliac pain. *Clin Orthop Relat Res* 2001; **382**: 112–8. doi: <https://doi.org/10.1097/00003086-200101000-00017>
- Jurik AG, Hansen J, Puhakka KB. Effective radiation dose from semicoronal CT of the sacroiliac joints in comparison with axial CT and conventional radiography. *Eur Radiol* 2002; **12**: 2820–5.
- Battistone MJ, Manaster BJ, Reda DJ, Clegg DO. Radiographic diagnosis of sacroiliitis—are sacroiliac views really better? *J Rheumatol* 1998; **25**: 2395–401.
- Rudwaleit M, Landewé R, van der Heijde D, Listing J, Brandt J, Braun J, et al. The development of assessment of SpondyloArthritis international society classification criteria for axial spondyloarthritis (Part I): classification of paper patients by expert opinion including uncertainty appraisal. *Ann Rheum Dis* 2009; **68**: 770–6. doi: <https://doi.org/10.1136/ard.2009.108217>
- van der Linden S, Valkenburg HA, Cats A. Evaluation of diagnostic criteria for ankylosing spondylitis. A proposal for modification of the New York criteria. *Arthritis Rheum* 1984; **27**: 361–8.
- Vogler JB, Brown WH, Helms CA, Genant HK. The normal sacroiliac joint: a CT study of asymptomatic patients. *Radiology* 1984; **151**: 433–7. doi: <https://doi.org/10.1148/radiology.151.2.6709915>
- Fafila CP, Prassopoulos PK, Daskalogiannaki ME, Gourtsoyannis NC. Variation in the appearance of the normal sacroiliac joint on pelvic CT. *Clin Radiol* 1998; **53**: 742–6. doi: [https://doi.org/10.1016/S0009-9260\(98\)80316-4](https://doi.org/10.1016/S0009-9260(98)80316-4)
- Geijer M, Gadeholt Göthlin G, Göthlin JH. The validity of the New York radiological grading criteria in diagnosing sacroiliitis by computed tomography. *Acta Radiol* 2009; **50**: 664–73. doi: <https://doi.org/10.1080/02841850902914099>
- Landis JR, Koch GG. An application of hierarchical kappa-type statistics in the assessment of majority agreement among multiple observers. *Biometrics* 1977; **33**: 363–74. doi: <https://doi.org/10.2307/2529786>
- Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics* 1977; **33**: 159–74. doi: <https://doi.org/10.2307/2529310>
- Sharma D, Manipal P. Influence of age and gender on sacro iliac joint space measured on computed tomography. *Int J Sci Res* 2015; **59**: 190–4.
- Geijer M, Sihlbom H, Göthlin JH, Nordborg E. The role of CT in the diagnosis of sacro-iliitis. *Acta Radiol* 1998; **39**: 265–8. doi: <https://doi.org/10.1080/02841859809172191>
- Hohl C, Mahnen AH, Klotz E, Das M, Stargardt A, Mühlenbruch G, et al. Radiation dose reduction to the male gonads during MDCT: the effectiveness of a lead shield. *AJR Am J Roentgenol* 2005; **184**: 128–30. doi: <https://doi.org/10.2214/ajr.184.1.01840128>
- Gurung J, Khan MF, Maataoui A, Herzog C, Bux R, Bratzke H, et al. Multislice CT of the pelvis: dose reduction with regard to image quality using 16-row CT. *Eur Radiol* 2005; **15**: 1898–905. doi: <https://doi.org/10.1007/s00330-005-2720-2>
- Friedman L, Silberberg PJ, Rainbow A, Butler R. A limited, low-dose computed tomography protocol to examine the sacroiliac joints. *Can Assoc Radiol J* 1993; **44**: 267–72.
- Lawson TL, Foley WD, Carrera GF, Berland LL. The sacroiliac joints: anatomic, plain roentgenographic, and computed tomographic analysis. *J Comput Assist Tomogr* 1982; **6**: 307–14.
- Carrera GF. Computed tomography in sacroiliitis. *Clin Rheum Dis* 1983; **9**: 403–41.
- Geijer M, Gadeholt Göthlin G, Göthlin JH. Diagnosis and progression of sacroiliitis in repeated sacroiliac joint computed tomography. *Arthritis* 2013; **2013**: 659487. doi: <https://doi.org/10.1155/2013/659487>