Evaluation of Manual Angulation Fixed Focal Approach Using Flat Panel Detector in Digital Radiography of Scoliosis

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Scoliosis patient underwent numerous spine radiographs during their monitor and treatment period, thus, may expose them to high accumulative radiation dose. In this study, the diagnostic performance of the flat panel detector (FPD) fixed focal approach with manual angulation was evaluated in term of accuracy and consistency of Cobb angle measurement, spatial accuracy as well as radiation dose to the patients compared to the conventional photostimulable phosphor (PSP) approach. Cobb angle measurements were evaluated with two special constructed human vertebrae phantoms. The intraclass correlation coefficients (ICC) for interobserver variation and percentage of accuracy in Cobb angle measurement were calculated. The significant differences in angle measurement between both approaches were assessed. The spatial accuracy was evaluated with TO.M1 phantom. Dose measurements were performed with radiochromic film and 20 cm polymethyl methacrylate (PMMA) slabs. The FPD fixed focal approach showed excellent interobserver reproducibility (ICC, \( r = 0.99, p < 0.05 \)) for the Cobb angle measurement. There was no statistically significant difference (\( p > 0.05 \)) for the Cobb angle measured from both approaches. The FPD fixed focal approach resulted in higher accuracy (3%) of angle measurement compared to the conventional PSP approach. The spatial accuracy was within the recommended limit of AAPM report 93. An average entrance surface dose (ESD) reduction of 20% was achieved with FPD fixed focal approach. We developed and evaluated a manual tube angulation method which facilitates the use of existing FPD digital radiography system to produce full spine image. It has good consistency and high accuracy in the measurement of Cobb angle. The acquired images are suitable for angle measurement for scoliosis patients with substantial dose reduction.

Keywords: Scoliosis Radiography, Digital Imaging, Flat Panel Detector, Photostimulable Phosphor, Fixed Focal Approach.

1. INTRODUCTION

Scoliosis is defined as the lateral curvature of the spine in coronal plane with a Cobb angle measurement of more than 10°.1 Idiopathic scoliosis is the most common type of scoliosis and accounts for 80% of the total cases of scoliosis in the USA.2 The Cobb angle measurement was introduced by John Robert Cobb, an American orthopedic surgeon.3 It is the standard for diagnosis, epidemiological analysis, monitoring and therapeutic intervention of scoliosis. Patients who have a scoliotic curve with Cobb angle of more than 50° have a higher rate of decreased pulmonary function. The curves with a Cobb angle of more than 80° with thoracic apex was associated with decrease in the vital capacity of the lungs and more frequent shortness of breath.4

Scoliosis patients are usually scheduled for numerous spine radiographs over a long period of time (up to several years) to monitor the curve progression and this may expose them with relatively high accumulated radiation dose. The effective dose for scoliosis radiography ranges from 0.118 to 0.160 mSv for the frontal projection which is equivalent to 18 to 243 days of background equivalent radiation dose (BERT) and from 0.097 to 0.137 mSv for the lateral projection which is equivalent to 15 to 217 days of BERT.5,6 Moreover, the majority of the scoliosis patients are children and adolescents who have greater radiosensitivity and face higher risk of developing fatal cancer in their lifetime.7

Since the early 1990s, there has been rapid technological progress in the development of digital radiography. Computed radiography (CR) is a cassette-based system, consisting of a photostimulable phosphor (PSP) and a plate reader system. In the early 2000s, direct conversion of the incident X-rays into electrical signals had been achieved with the introduction of flat panel detector (FPD).8 Digital radiography (DR) using FPD has