Research study

Region of Interest in the radiological follow-up of patients with scoliosis

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Abstract

Introduction
Patients with scoliosis are subjected to multiple X-ray investigations during growth. The need for X-ray investigations during regular check-ups, when clinical measurements are taken, can be reduced angle of trunk rotation, surface topography. However, as indications and check-ups still rely on the measurement of the Cobb angle on a full standing X-ray, the exposure of children and adolescents with scoliosis cannot be avoided. Therefore, it would be sensible to drastically reduce the exposure of this patient group to radiation.

One way to reduce the exposure of this patient group to radiation is through reduction of the exposure time; the other way is the reduction of the diagnostic field. This study was undertaken to investigate the possibility of using a single 45 × 45 cm detector of a digital radiography system for the diagnosis and follow-up of adolescent girls with scoliosis.

Materials and methods
Thirty-two consecutive standing X-rays of girls aged 10 to 14 years, produced with a single 45 × 45 cm detector of a digital radiography system, were analysed to see if sufficient information had been provided for the diagnosis and follow-up of these patients.

Results
Ground plate of Th1 was clearly visible in 31% of patients, ground plate of Th2 in 56% of patients and ground plate of Th3 in 88% of the patients. Major curvatures (thoracic and lumbar) were fully visible in 100% of those tested. Risser 3 or 4 was detected in 100% of cases.

Conclusion
Adolescent girls with scoliosis can be checked-up and diagnosed with a drastic reduction of the diagnostic field using a 45 × 45 cm detector of a digital radiography system for direct radiography. A drastic reduction in the exposure to radiation of children and adolescents with scoliosis is easily possible by reducing the diagnostic field (window) and by reducing the exposure time. For proper diagnosis and check-up, it is rarely necessary to expand the field size to higher than the Th3 level.

Introduction
Scoliosis is a three-dimensional deformity of the spine and trunk, which may deteriorate quickly during periods of rapid growth. Although scoliosis may be the expression of or a symptom of certain diseases, e.g., neuromuscular, congenital or due to certain syndromes or tumours, the majority of the patients with scoliosis (80%–90%) are called ‘idiopathic’ because a certain underlying cause has still not been found. The treatment of symptomatic scoliosis may primarily be determined by the underlying cause. The treatment of the so-called idiopathic scoliosis is determined by the deformity itself. As scoliosis progresses mainly during the growth phase with some progression also seen later in life, the main aim of any intervention should be to stop curvature progression.

While children grow until they have fully matured, there are certain times with more or less growth during childhood and adolescence, and curvature progression is more or less probable during these different phases of growth.

With the first signs of breast development or pubic hair, the pubertal growth spurt begins (P1) and in its ascending phase, before the onset of menarche, two-thirds of progression may occur. Shortly after the growth peak (P3), menarche in girls/voice change in boys appears to indicate the onset of the descending phase of growth up to its cessation (P5).

In patients with idiopathic scoliosis, during adolescence, the risk of being progressive can be calculated using the formula developed by Lonstein and Carlson. Based on this formula, the treatment indications for patients with scoliosis during growth are determined.

Scoliosis, simply defined as a lateral curvature of the spine, has been recognised clinically for centuries. The deformity is actually much more complex, and in order to describe it more accurately and quantify the scoliosis deformity, three-planar and three-dimensional terminology and measurements are required. However, for practical purposes, the deformity is most conventionally measured on standing coronal plane radiographs using the Cobb technique (Figure 1).

For the estimation of the actual risk of progression, we also have to determine the maturity of the patients. Therefore, the Risser sign has been proposed and is still widely used today. The Risser sign is determined by rating the maturity of the apophyse of the iliac crest (Figure 2).

While premenstrual girls at average have Risser 0, the Risser sign arises after the onset of menarche.
Research study

Figure 1: Full standing X-ray with Cobb-angle measurement. The most tilted and least rotated vertebra is measured as can be seen on the right. The head and full pelvis is visible without providing any information.

Figure 2: Standing X-ray from the sample of this study showing the Risser sign. The iliac crest is fully visible and the apophyse (arrows) is not yet closed. Th1 is also visible on the picture, so the full thoracic and full lumbar spine can be measured.

Adolescent idiopathic scoliosis (AIS) is the most frequent diagnosis of scoliosis2. Its prevalence is very dependent on curve size cut-off point, decreasing from 4.5% for curves of 6° or more2, to only 0.29% for curves of 21° or more2. It is also very dependent on sex, being equal for curves of 6°–10°, but showing a ratio of 5.4 girls to 1 boy for curves of 21° or more2. The bigger the curve, more the number of girls involved, with a girls to boys ratio of 10:1 in curvatures exceeding 40°2.

Scoliosis patients are subjected to multiple X-ray investigations during the period of growth. Because the risk of getting cancer has increased in this population10–13, ways to reduce the amount of radiation have to be determined.

One can reduce the need for X-rays during the regular check-ups when clinical measurements are taken angle of trunk rotation, surface topography, however, as indications and check-ups still rely on the measurement of the Cobb angle on a full standing X-ray7,8, the exposure of children and adolescents with scoliosis cannot be avoided. Therefore, it seems sensible to drastically reduce the exposure of this patient group to radiation.

One way to reduce radiation is through the reduction of the exposure time which we have already proposed earlier14. The other way is through the reduction of the diagnostic field (window).

This study was undertaken to investigate the possibility of using a single 45 × 45 cm detector of a digital radiography (DR) system for the diagnosis and follow-up of adolescent girls with scoliosis using a single shot.

Materials and methods

This work conforms to the values laid down in the Declaration of Helsinki (1964). The protocol of this study has been approved by the relevant ethical committee related to our institution in which it was performed. All subjects gave full informed consent to participate in this study.

Thirty-two consecutive standing X-rays of girls aged 10 to 14 years, produced with a single 45 × 45 cm detector of a DR system, were analysed as to whether sufficient...
information had been provided for diagnosis and check-ups of the patients under observation or for treatment with a brace.

Results

Ground plate of Th1 was clearly visible in 31% of patients, ground plate of Th2 in 56% of patients and ground plate of Th3 in 88% of the test population. Major curvatures (thoracic and lumbar) were fully visible in 100% of the population. Risser 3 or 4 was detected in 100% of the population.

Discussion

As has been shown in the typical population of the most prevalent diagnosis of scoliosis (AIS), the radiation field size can be reduced drastically without losing a significant amount of information. We have been testing the radiographs of girls between 10 and 14 years of age, the typical population in a conservative bracing practice where the patients are checked-up quarterly. During this period of time, at many centres, full standing X-rays (antero-posterior [ap]) and lateral X-rays are performed (Figure 3), most of these being unnecessary.

Most of the X-rays performed quarterly do not respect the possible measures to reduce radiation (Figure 1 and 4). The head and full pelvis is visible without providing any information. The lateral X-rays, obviously regularly performed (Figure 3), also do not provide any information that could not be measured or even estimated clinically. However, the dose of radiation is even higher in lateral full standing X-rays compared to (ap) X-rays.

With the technique proposed in this paper, we can significantly reduce the surface (window) exposed to radiation without losing important information (Figure 5). In the rare cases of a spinal malformation cranially to the vertebra, an additional X-ray of a specified region of interest (ROI) can be taken. This can also be done on patients taller than the typical population of adolescent girls.

Bracing in the treatment of patients with scoliosis is the only treatment with evidence on a higher level. During the period of bracing, X-rays in the brace are necessary to see the in-brace correction and the level of the pressure areas.

Therefore, a significant reduction of the exposure to radiation is necessary in adolescents under treatment. This can be achieved in the following ways: (1) by reducing the window of radiation and (2) by reducing the exposure time as discussed earlier.

This technique, of course, has room for improvement. In many of the X-rays from this series, the S3 level was on the picture caudally, while cranially, we would have liked to see Th1 which was unfortunately not visible.

This paper can be viewed as a preliminary report. We will eventually increase the number of X-rays in the same population and also analyse the data of the individual X-rays statistically.

With increasing use of the 45 × 45 cm detectors for DR systems, the exposure to radiation of the scoliosis patient is reduced.
patients seems to increase. While the full standing X-ray was/is possible using a single shot and a long film, today, two or three shots are used and the single pictures are then merged together to produce a long digital full standing picture (Figure 6). This increases the exposure to radiation drastically and cannot be recommended for following up patients with scoliosis when the ROI can be reduced to sometimes less than a quarter of the full standing picture, as can be seen in Figure 6.

Conclusion
Adolescent girls with scoliosis can be checked-up and diagnosed with a drastic reduction of the diagnostic field using a 45 × 45 cm detector of a DR system for direct radiography. A drastic reduction of the exposure to radiation of children and adolescents with scoliosis is easily possible by reducing the diagnostic field (window) and by the reduction of the exposure time. For proper diagnosis and check-up, it is rarely necessary to expand the field size higher than the Th3 level.

Abbreviations list
AIS, adolescent idiopathic scoliosis; ap, antero-posterior; DR, digital radiography; ROI, region of interest.

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Figure 6: Left; three single pictures taken with a using a 45 × 45 cm detector of a DR system for direct radiography. In the middle, the three pictures have been merged together producing one long standing picture of the X-ray, however, this X-ray has been produced with three shots of radiation. On the right, the ROI is shown which could have been taken using a 45 × 45 cm detector of a DR system for direct radiography with a single shot. Additionally, all mandatory and recommended measures to reduce unnecessary radiation besides reducing the window to the ROI have been ignored in these pictures. The pictures shown here have been developed in a hospital in Asia.

Figure 5: Left, patient without brace clinically and radiographically with a curve measured 43°; right, patient in the brace with a full correction of the curvature. The reduction of the diagnostic field did not reduce the necessary information on both X-rays.
References