A Quality Improvement Initiative to Reduce Radiation Dose During Cast Treatment for Infantile Scoliosis

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Abstract: Assessing the progress of treatment and effectiveness of casting for early onset scoliosis (EOS) requires frequent use of radiographs which increases the risk of malignancy in young patients over their lifetime. In an effort to decrease radiation risk we began a quality improvement (QI) project based on a simple change in spine radiograph techniques. Traditionally, a grid is placed between the patient and cassette to absorb radiation scatter. We eliminated the use of a grid in our practice and were able to lower the dose accordingly to optimize endplate visualization. To ensure that measurement accuracy was not severely decreased, inter- and intra-rater variability was measured before and after this change by several observers. Obtaining spinal radiographs without the grid resulted in an 80% reduction in total radiation dose received at the skin while having no effect on inter- and intra-rater reliability of Cobb angle measurements. These radiographs allow for monitoring of treatment progress and cast quality with each anesthetic. We are currently investigating a similar technique for longitudinal follow up pelvis radiographs in the treatment of hip dysplasia and cerebral palsy.

Key Concepts:

- Radiographs of the spine do not have to be of full diagnostic quality for purposes of longitudinal follow up.
- Spinal radiographs taken without the grid are grainy, but it is still possible to discern the end plates for Cobb angle measurements.
- Eliminating the grid while obtaining spinal radiographs allows the dosage of radiation to be reduced by 80%.

Introduction

Serial Elongation, Derotation, Extension (EDF) casting is a commonly used treatment method for Early Onset Scoliosis (EOS) and radiographs are obtained before and after to determine the progress of treatment. While these are standard; multiple radiographs in very young children make them susceptible to the damaging effects of ionizing radiation.[1] Research into diagnostic radiation exposure in children has demonstrated increased risk of not only fatal pediatric cancer, but also development of heritable defects, future fertility problems, and eventual development of adult cancer.[2,3,4,5] One study demonstrated increased lifetime risk of mortality and

cancer, and several studies have demonstrated females with adolescent idiopathic scoliosis (AIS) are at increased risk for developing breast and uterine cancer.[8,9,10,11]

The management of infantile scoliosis requires the frequent use of radiography.[6,7] In order to lower the dosage of radiation, some have developed low dose protocols, specific radiographic sequences, improved technology and even omit radiographs during visits.[12,13,14,15] Yet there is risk when omitting radiographs; some surgeons may find the quality of casting difficult to assess and the potential of time lost in a poorly molded cast. Parents also want to reduce radiation exposure, yet they want information about the quality of casting and progress of treatment at each anesthetic.

High quality spinal radiographs are obtained with a grid placed between the patient and the detector; this reduces scatter that occurs when imaging through the trunk.[16] A grid is a thin metal case placed over the detector that contains tightly spaced metal fins that absorb any radiation that has been deflected by the soft tissues in the body and is no longer travelling perpendicular to the detector. The grid allows for a sharply contrasted image of high diagnostic quality. The grid requires the dosage of ionizing radiation to be increased by a factor of four.[17] While we found radiographs without the grid were grainy; when only evaluating Cobb angle, the endplates are readily discernable. We report our experience in dose reduction, technique adjustment, and measurement accuracy in a quality improvement initiative. Our goal is to allow radiographs to be obtained when needed that still allow for accurate measurement of Cobb angle and assessment of cast quality, at significantly reduced radiation doses, so that valuable anesthetic events will not be potentially wasted.

Methods

This quality improvement initiative took place at our Pediatric Orthopedic Specialty Hospital with two surgeons experienced in EDF casting. Spinal radiographs for EDF casting are usually obtained with a portable X-ray machine under general anesthesia just before and after casting. We discussed strategies to reduce radiation exposure with our radiology staff and our institution's radiation physicist. While nonconventional, one potential solution was to eliminate the grid from our technique. Without the grid, the radiation dose delivered could be reduced by at least 75% but we were told the images would be grainy. After attempting this once, we found the images to be satisfactory for identification of the endplates and for measurement of Cobb angles.

Prior to March 2018, all intraoperative spine radiographs were taken with standard technique utilizing a grid. In an effort to decrease radiation exposure to patients, the grid was removed for all patients undergoing spine radiographs for early onset scoliosis after March 2018, resulting in approximately 20% of the radiation dose (mAs) with this technique compared to standard technique (5 mAs average with a grid and 1.5 mAs without). After several patients were imaged in this manner, we felt quite comfortable that the image quality was sufficient for Cobb angle measurement and have not reverted back to standard technique.

To be sure that measurement accuracy was not significantly reduced, 22 patients with infantile scoliosis in our EDF casting program were identified for a quality improvement assessment. Some patients were treated entirely before or only after our change in technique, but most had radiographs that spanned over this period. Four surgeons (two attending physicians and two resident physicians) recorded Cobb angle measurements twice, on blinded radiographs, a minimum of two weeks apart on the same PACS workstation. Cobb angle measurements for the largest curve were utilized via de-identified radiographs within the Phillips PACS system. Intraclass correlation coefficient (ICC) with a 95% confidence interval (CI) was used to evaluate inter-observer and intra-observer agreement for Cobb angles.

A p-value < 0.05 was considered statistically significant. This project was undertaken as a quality improvement initiative at Shriners Hospitals for Children and was exempted from formal review by Western IRB.

Results

In consultation with our radiologist and radiation physicist (who estimated the dosage required); first non-grid radiograph was performed in the operating room before EDF casting. We kept the Kv unchanged and reduced the mAs by 50%, yet this resulted in an overexposed film. In the next attempt, we kept the Kv unchanged but reduced mAs to 25% of the original dose. The results were of surprisingly sufficient quality and since the dose reduction was so dramatic, no other adjustments were made (Figure 1a and 1b).

Both surgeons adopted this as the new standard moving forward and continued obtaining radiographs at the same intervals as before. We did not find any radiographs that were unusable and only small adjustments in mAs are required by the radiographers for weight, presence of a cast, cast materials, and distance between the cathode and subject.

Dosage calculations demonstrated a reduction in radiation dose measured at the skin from 0.62 mSv with grid to 0.12 mSv without grid. This represents a reduction of 80% in the radiation dose measured at the skin. Five radiographs taken with this technique produce the same radiation dose as one taken with the standard technique.

In order to ensure quality with this change, Cobb angles were measured on a total of 71 radiographs. Twenty-eight radiographs were performed with grid, and 43 radiographs were performed without a grid. Three measurements within the data set were excluded from data analysis given measurement error within the PACS system. All three excluded data points were within the grid class. Re-measurement of these levels were deferred to limit bias from the analysis. There was no significant

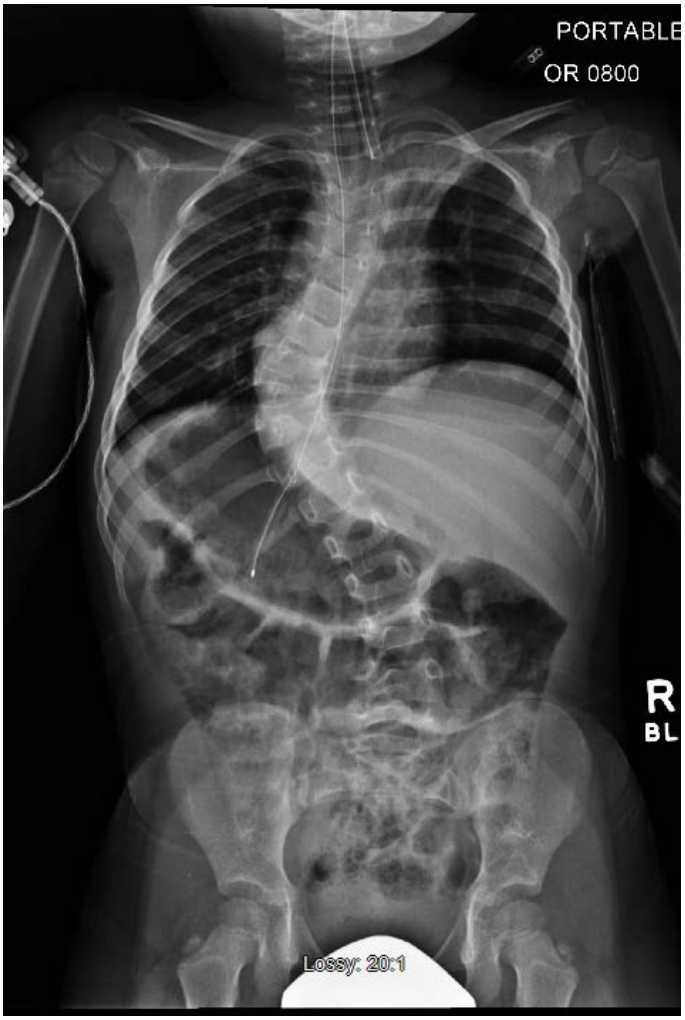

***Figure 1a**. A typical pre-casting radiograph is obtained with a grid.*

reduction in inter- or intra-rater reliability attributable to the removal of the grid.

The ICC among staff and resident surgeons with and without a grid ranged from 0.96 – 0.99 in both groups (p < 0.001). The average standard deviation between measurements for the grid and non-grid data sets were both 2.75°. On the basis of this assessment we are confident that the improvement in patient safety by radiation reduction did not affect the needed quality to assess our casting technique. One unexpected benefit of this quality improvement initiative is that we now routinely omit the grid for any follow-up radiograph of the pelvis done for patients with hip dysplasia or

cerebral palsy. We are currently studying the effects of this intervention on the accuracy of measurements of migration index and acetabular index.

Discussion

In summary, sharply contrasted radiographs (obtained with a grid) are not required for the routine monitoring of treatment in patients undergoing EDF casting for early onset scoliosis. The images obtained with this method are grainy but allow for satisfactory measurement of Cobb angles and therefore the progress of treatment and quality of each individual cast. In 2009, Mehta et al. demonstrated an intraclass correlation coefficient of 0.978 for Cobb angles measured via endplates and our results were similar.[18] In addition, with this method we can still provide critical assessment of window and trim line assessment, and monitor for potential adverse effects of casting such as iatrogenic rib deformities. While our quality improvement initiative does not eliminate exposure to radiation, the progress of treatment and effectiveness of each individual cast can be monitored without the risk of a potentially wasted anesthetic.[19]

In any course of treatment where multiple radiographs are required over time, it is important to ask what the minimum information is needed from the study. While the first image may need to be obtained with a grid to ensure diagnostic quality, subsequent radiographs have a far more limited role. Our center now uses this technique routinely in the operating room setting but also in clinic for follow up of patients with scoliosis who are too young for the EOS machine or need radiographs obtained supine for other reasons (unable to stand). We are beginning to study this technique for pelvis radiographs as well. Treating physicians, Radiology department staff and patient safety officials are very satisfied with this intervention.

Numerous strategies to decrease radiation exposure in pediatric scoliosis patients have been studied. The most marked decrease in radiation exposure comes from the use of slot beam digital radiography, or the EOS machine. Hui et al. demonstrated up to a 26 times reduction in radiation exposure compared to standard digital radiographs.[12] Unfortunately, this technology requires the patient to stand upright and still for up to 20 seconds for image acquisition and therefore is not useful for EDF cast treatment. The technique we describe allows the images to be obtained without special equipment in a supine position, allowing for a reduction in the dose at the skin by 80%.

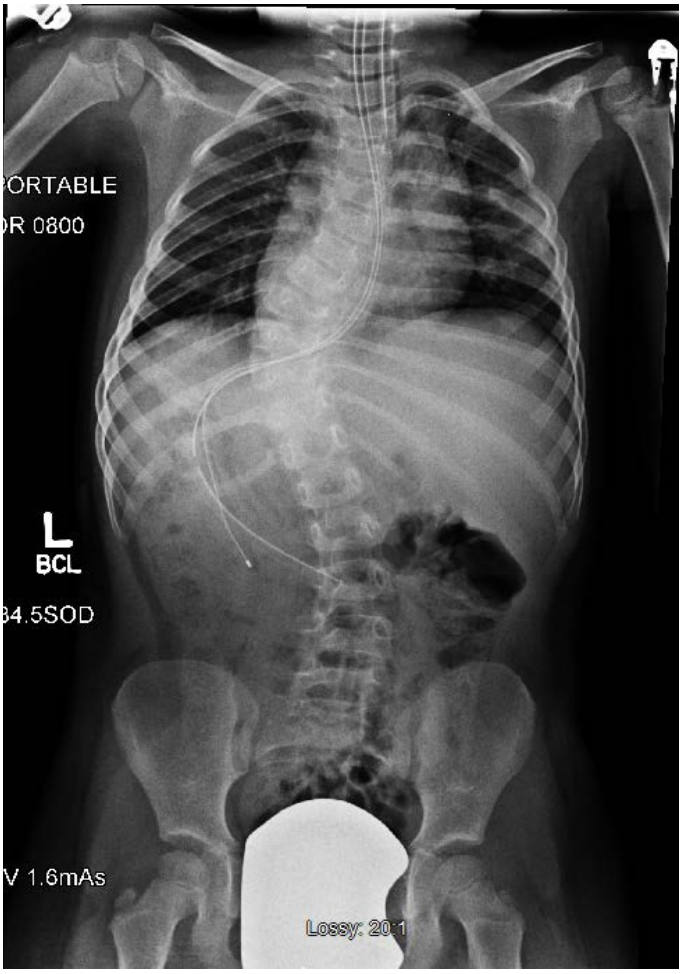

Figure 1b. *Pre-casting radiograph on the same patient obtained without a grid. The endplates are less well defined but still discernable.*

Conclusion

This quality improvement initiative has shown that removal of the grid for standard spine radiographs in

patients with early onset scoliosis does not compromise reliability of Cobb angle measurements. In addition to the five-fold reduction in radiation exposure inter- and intra-rater reliability of Cobb angle measurements performed without grids were comparable to those performed with grids. We would, however, recommend at least one radiograph, near the beginning of treatment, be performed with the standard technique so that it can be of diagnostic quality for the purposes of complete diagnostic radiology interpretation. This method may be a useful and safe tool for the pediatric orthopedic surgeon managing early onset scoliosis. This method may also be generalizable to pelvis radiographs obtained for the longitudinal follow-up of hip dysplasia or neuromuscular hip displacement.

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Additional Links

http://www.posnacademy.org/media/1_o0ergoq3

http://www.posnacademy.org/media/Mehta+Casting/1_ovqt15hr

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