

An Innovation of Radiation Shielding for Safety of Whole Spine Radiographs

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Abstract

OBJECTIVES: Whole spine radiographs are common procedure in routine practice for scoliosis patients. The incidence of repeated radiograph is a point of awareness-raising for increasing radiation dose, increasing cost, and rising procedure time. A pelvic radiation shielding plays an important role to protect the gonads and decreased incidence of repeated radiographs. That leads to an innovation of the new shielding: safe and user-friendly, from our department.

MATERIALS AND METHODS: A suitable shape for the new shielding of the pubic area is an inverted triangular shape. Its sizes were calculated from the measured parameters of pelvis anteroposterior (AP) radiograph as width of pelvic cavity, length of handling shielding from iliac crest to the widest point of pelvic cavity for female, and height from iliac crest to superior rim of pubic symphysis for male. Then, two sizes of rubber belt (length of handling shielding) for the shielding were made; 10 cm and 20 cm for female and male, respectively. The new lead plate was used in routine whole spine radiographs from June 2016 to April 2017. The repeated radiograph (rejected rate), rate of routine procedure time, rate of satisfactory to the new lead plate of radiologic technologists, and cost of repeated radiograph of whole spine (expense) were recorded during the whole period and sub-period.

RESULTS: The rejected rate of whole spine radiograph is less than 5%. The rate of routine procedure time within 4 minutes reached 95% in four months. The rate of satisfactory response to the new lead plate by technologists was about 85.2% in the first month of practice. Finally, cost of repeated radiograph of whole spine (expense) decreased about 65% in ten consecutive months.

CONCLUSIONS: The new inverted triangular lead plate for radiation shielding was an effective tool as it decreased the rejected rate, decreased procedure time, increased satisfactory response of radiology technologists, and decreased the expense.

Keywords: radiation shielding, safety of whole spine radiographs

Nowadays, whole spine radiographs are commonly evaluated tools for scoliosis patients in diagnostic and follow up radiographs. A standing position is mandatory for image acquisition of the whole spine; C1 down to sacrum. The images are later fused into only one image (Figure 1).

Radiation shielding at the pubic area is the most concerning after several radiographs are taken, especially in teenager or puberty patients (Figure 2).¹

According to the database of the Department of Radiology, Bangkok Hospital Headquarters in 2015, there were some incidences of repeated radiographs as follows: whole spine radiographs 39%; knee radiographs 33%; chest radiographs 20%; abdomen radiographs 1%; and others 7%. The repeated whole spine radiographs is a double radiation dose, raising the cost to 103,016 baht/month on average, and rising the procedure time by 3 minutes; approximately 75% of the routine procedure time (routine procedure time is 4 minutes).

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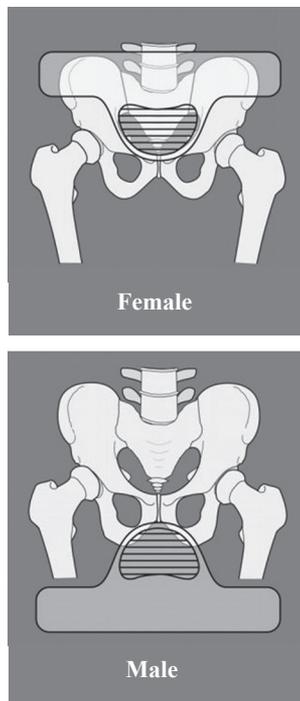


Figure 1: Shows x-ray whole spine AP view with a gonad shield of the pelvic cavity.

Figure 2: Shows ideal position of a gonad shield in the female and male patient.¹

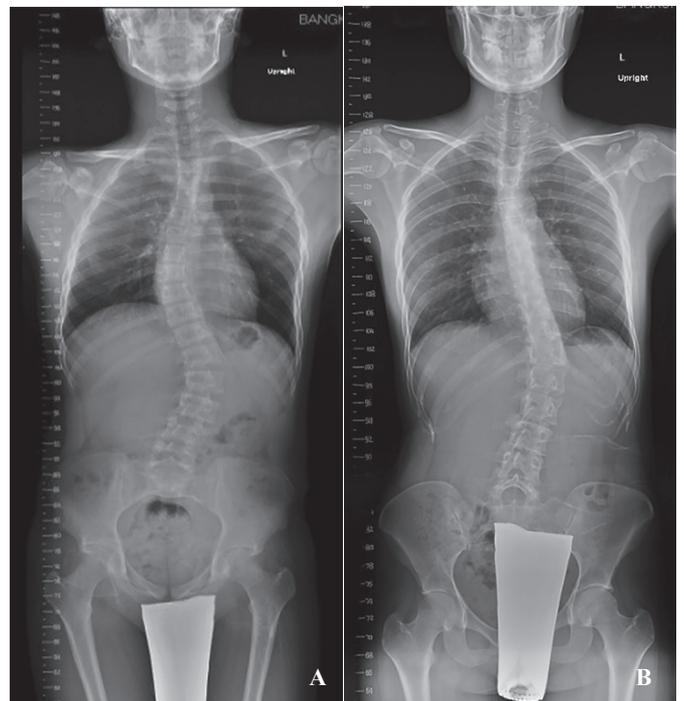


Figure 3: Shows malpositioning of the shielding.
A: the shielding was improperly placed.
B: the shielding was properly placed with errors in the pelvic cavity.

The causes to the problems found in repeated radiographs are as follows: 11% patient motion, 29% patient positioning error, and 60% malpositioning of the shielding (Figure 3). Patient safety is the key of universal patient care. As a result, a new innovation of radiation shielding of the pubic area was invented in our department for whole spine radiographs.

Materials and Methods

The most common material of radiation shielding is lead plate. The inverted triangular shape is suitable for radiation shielding of the pubic region in both male and female patients (Figure 4).² The size of the new lead plate was calculated from the average measurement of the distance between the medial rim of the bilateral iliac wings; the widest point, in both sexes from the pelvis AP radiograph. Also the length of the handling shielding was measured from the average distance of the iliac crest to the superior rim of the pubic symphysis for males, and to the widest point of the pelvic cavity for females, from the pelvis AP radiograph (Figure 4).

The radiation shielding, the inverted triangular lead plate, was attached to a rubber belt at the upper rim, to be placed at the iliac crest of patients. The x-ray beam can pass through the rubber belt, and resulted in no artifact on the radiographs.

We reviewed 200 pelvic AP upright radiographs, half male and half female, with an average age between 18 and 70 years (Table 1), to measure the width and height as mentioned above and to calculate an average measurement:

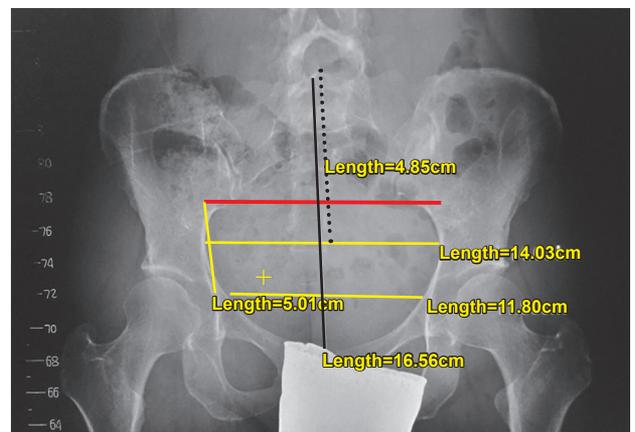


Figure 4: Shows the measurements taken for the new innovative shielding

- For females: the average distance of ipsilateral iliac crest to the widest point of the pelvic cavity at the medial rim of the ipsilateral iliac bone, was 10 cm, the average width of the pelvic cavity was 13.85 cm (Figure 5).
- For males: the average distance of the ipsilateral iliac crest to the superior rim of the pubic symphysis was 20 cm, the average wide of pelvic cavity was 12.93 cm (Figure 6).

The thickness of the inverted triangular lead plate shielding was about 0.5 mmPb demonstrated a radiation transmission only 0.4-2.2% which was a shielding, standard value, then, covered by cotton, and oil shielding for water resistance. Two sizes of rubber belt for the shielding were made; 10 cm and 20 cm for female and male respectively. The bilateral rims of the shielding were then folded inside by 1.5 cm. each, avoiding the hip joint overlap (Figure 7). The iliac crest was the guide used to adjust the position of the lead plate, holding on the midline (Figure 8).

The new lead plate was used in routine whole spine radiographs from June 2016 to April 2017, then repeated radiograph (rejected rate) was recorded. Rate of routine procedure time within 4 minutes was recorded from June 2016 to April 2017. Rate of satisfactory response to the new lead plate by radiology technicians was recorded from June 2016 to

December 2016. The cost of repeated radiograph of whole spine (expense) was also recorded from January 2016 to April 2017.

Table 1: Patient characteristics at baseline (n=49)

Details	n(%)
Gender	
Male	100 (50)
Female	100 (50)
Average of the age (years)	18 - 70
Average width of the pelvic cavity (cm)	
Male	12.93
Female	13.85

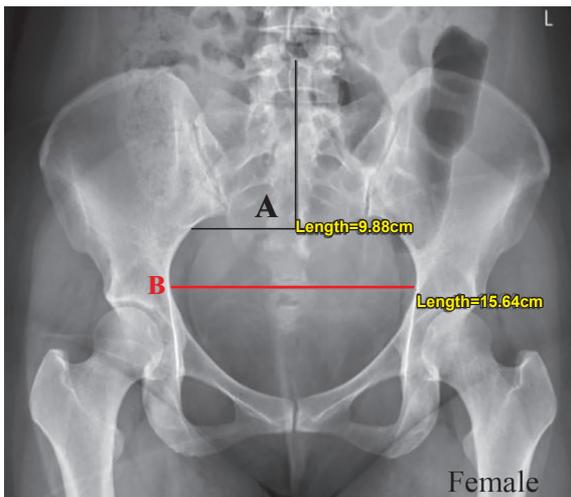


Figure 5: Female

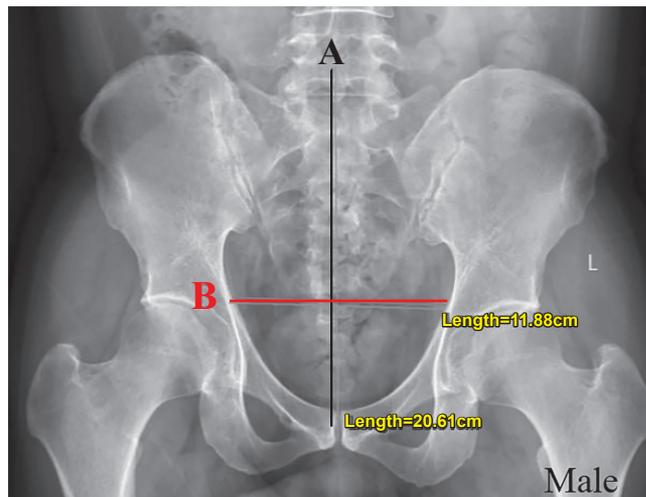


Figure 6: Male

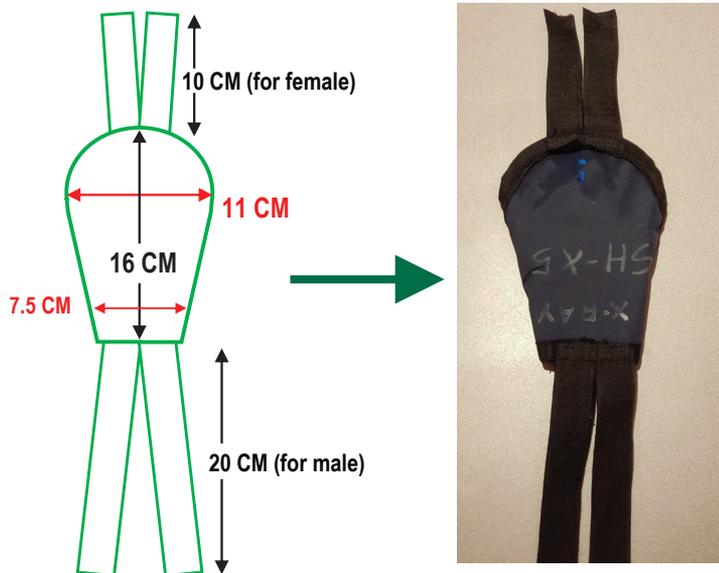


Figure 7: The size of lead protection for females is 10 cm from iliac crest, and for males it is 20 cm from iliac crest, using the same configuration and size.



Figure 8: Shows female using a gonad lead protection 10 cm from iliac crest.



Figure 9: Shows male using a gonad lead protection 20 cm from iliac crest.

Results

1. Rejected rate of whole spine radiograph. The rejected rate in the first month (June 2016) was about 8.3%, after that, we made the manual and taught the technologists. After this, the rate has been decreasing (Figure 10), to be less than 5%.

2. Rate of routine procedure time within 4 minutes was about 78.3% in June 2016. Then, we demonstrated to the technologists how the new shielding worked. The rate of improving procedure time was gradually increasing in July, August and September 2016 as 82.8%, 94.9% and 95% respectively (Figure 11).

3. Rate of satisfactory response to the new lead plate by radiology technologists was about 85.2% in June 2016. The technologists were satisfied with the new innovation. There were a few suggestions, including for example that the color of the new plate should be colorful. The rate of satisfactory response has been steadily increasing in the latter months as shown in Figure 12.

4. Cost of repeated radiograph of whole spine (expense) has decreased by about 65% from June 2016 to April 2017. The expense in September 2016 was rather higher than August 2016 due to increased numbers of total whole spine radiograph performed, but the rejected rate decreased (Figure 13).

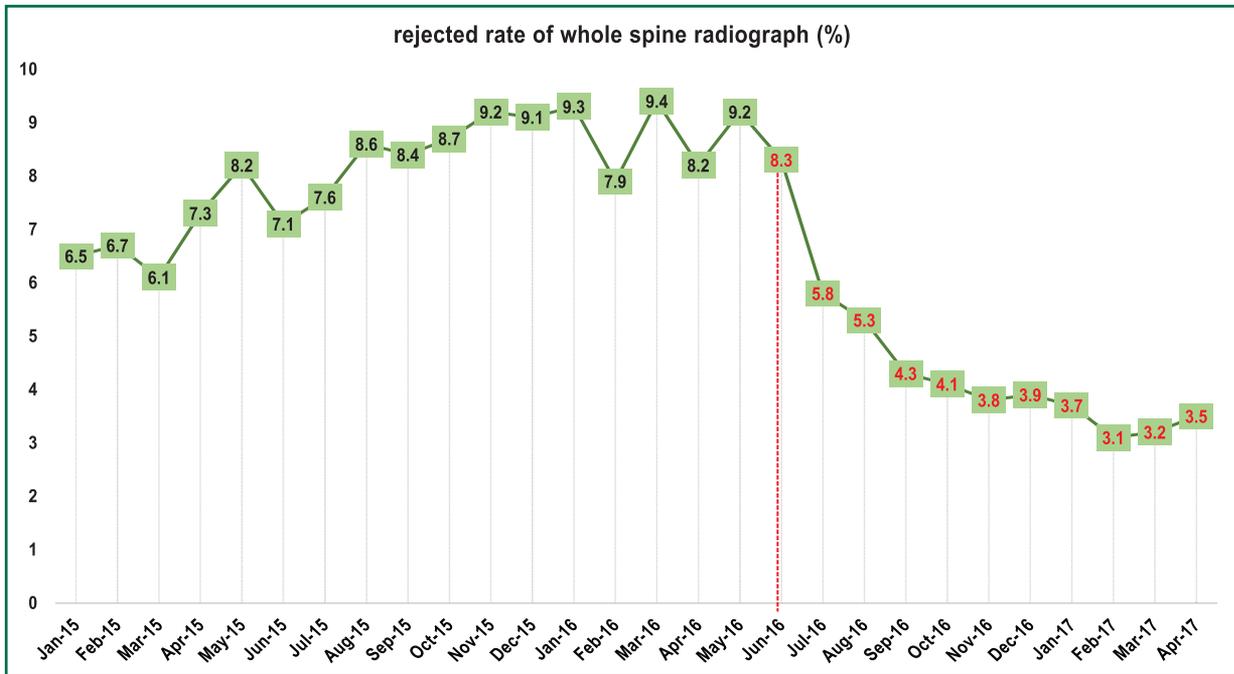


Figure 10: Reject rate of whole spine radiography per month.

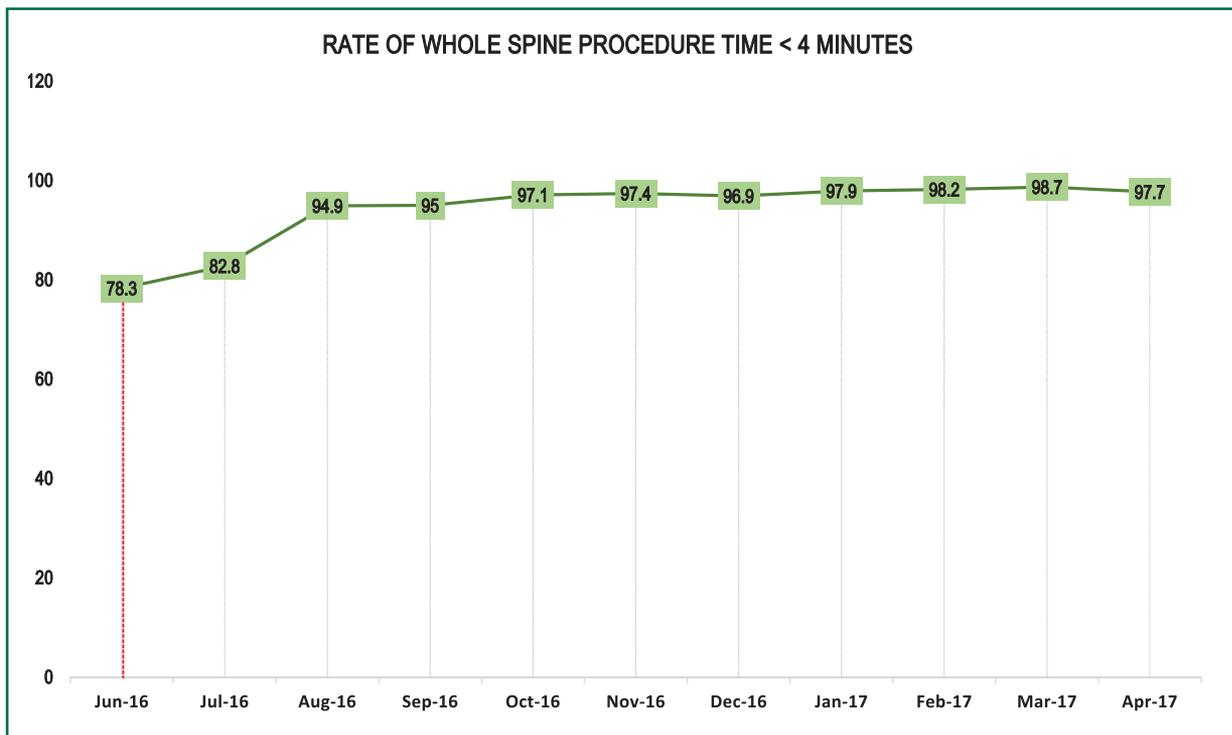


Figure 11: Rate of whole spine procedure time within 4 minutes.

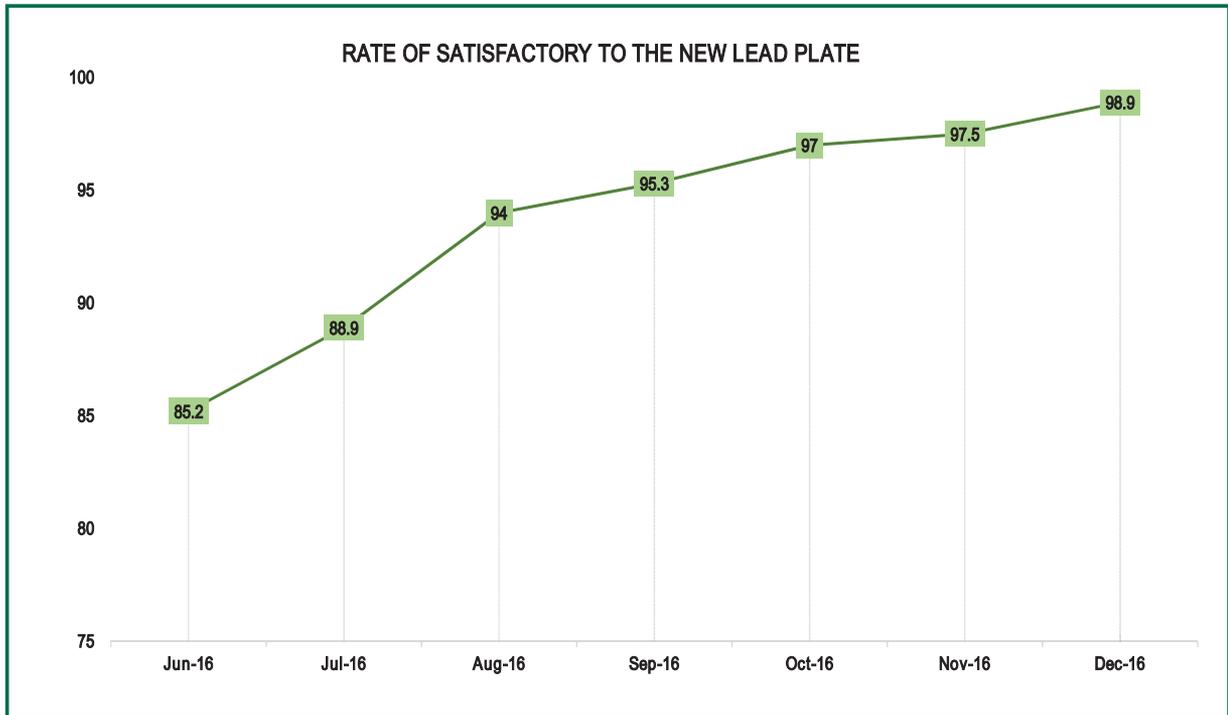


Figure 12: Rate of satisfactory response to the new lead plate of radiology technologists.



Figure 13: Cost of repeated radiograph of whole spine per month.

Discussion

In children and young adults, gonads are extremely sensitive to radiation exposure. Rowley MJ, et al.⁴ reported the effect of graded doses of ionizing radiation on human testes. Doses are 10-15 rad (0.01 to 0,015 Gy) can induce depression of spermatogenesis and the dose of more than 500-600 rad is likely to induce permanent sterility. In young girls, doses of 500 rem (5Sv) destroy germinal epithelium.⁵ The average total permissible gonadal dose per year was 0.013 rads for males and 0.035 rads for females.⁶ In all circumstances, radiation protection with lead shielding protection is important and needs to be in the proper position in either male or female patients. The positioning of the shielding should be confirmed as satisfactory for the patient's physician including the radiologist, chiropractor, and orthopedic physician. An adequate shielding should include the entire gonads in male and female. As these are different, female gonads are in pelvic cavity, hence the protection shield should cover the whole pelvic cavity in women, but it should not interfere with interesting structures such as the acetabulum and/or hip joints.^{1,2}

We present a lead shielding for gonads in both genders in case of whole spine study in the positioning and fixation of

the protection in place. We present an analysis of the rate of rejection, time procedure and expense. We found that the rate of rejection is less than 5%. Routine time procedure is 4 minutes achieving 97% rate, and the rate of satisfactory response in terms of fixation and being user-friendly is 95-98%. The expense cost of repeat examination decreased by 65% in ten consecutive months. From this study and analysis, we recommend the use of lead gonads shielding protection as per our configuration and size including male and female sizes as well as following our positioning protocol in the standing position. This innovative significantly reduces the rate of rejection, and the time this procedure takes. It is user-friendly and reduces expense.

Conclusion

The new inverted triangular lead plate for radiation shielding is an effective tool as it decreased the rejected rate, decreased procedure time, increased satisfactory response of radiology technologists and decreased expense. We strongly recommend this plate for routine whole spine radiographs over the conventional or commercial lead plate.

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