



## Fluoroscopic exposure in modern spinal surgery

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The widespread use of minimally invasive and other spinal procedures raises concern about the peroperative radiation exposure to surgeon and patient. The authors noted the fluoroscopy time and the radiation dose, as read from the image amplifier, in 95 spinal procedures. The results of this prospective study varied widely between different operations. Percutaneous surgery was associated with more exposure than open surgery. For instance, the average radiation dose per pedicle screw was 3.2 times higher with percutaneous insertion than with an open approach. Therefore, efforts to reduce fluoroscopy time and radiation exposure should be made when using minimally invasive percutaneous surgical techniques. Preventive measures for the surgeon, such as lead aprons and gloves, thyroid shields, radioprotective glasses and staying away from the beam are recommended. Still from the surgeon's view-point, source inferior positioning of the image amplifier is indicated for the AP view, as well as monitoring of the radiation exposure. Finally, the difference in fluoroscopy time and radiation exposure between surgeons for the same procedure stresses the fact that peroperative radiation may be reduced by simple awareness and by training.

**Keywords :** radiation ; radioprotection ; spinal surgery ; percutaneous surgery.

### INTRODUCTION

There is increasing concern about the peroperative radiation exposure to surgeon and patient, all the more so because minimally invasive spinal

surgery, highly dependent on fluoroscopy, is gaining popularity.

### MATERIALS AND METHODS

The authors prospectively studied the total radiation dose and the exposure time, read from the image amplifier, in 95 consecutive cervical and lumbar procedures, as currently performed in the 21st century, over a period of 18 months. Their purpose was to assess the safety of the procedures and to determine what the best practice would be. The radiation dose was measured in mGycm<sup>2</sup>. The patient was in the supine position for the cervical surgery, and in the prone position for all other procedures.

The surgical procedures studied were : Anterior Cervical Discectomy and Fusion (ACDF) (17 cases), cervical Total Disc Replacement (TDR) (11 cases), vertebroplasty (4 cases), kyphoplasty (12 cases), Posterior Lumbar Interbody fusion (PLIF) (28 cases), percutaneous lumbar fusion (3 cases), and percutaneous insertion of an Interspinous Process Device (IPD) (20 cases).

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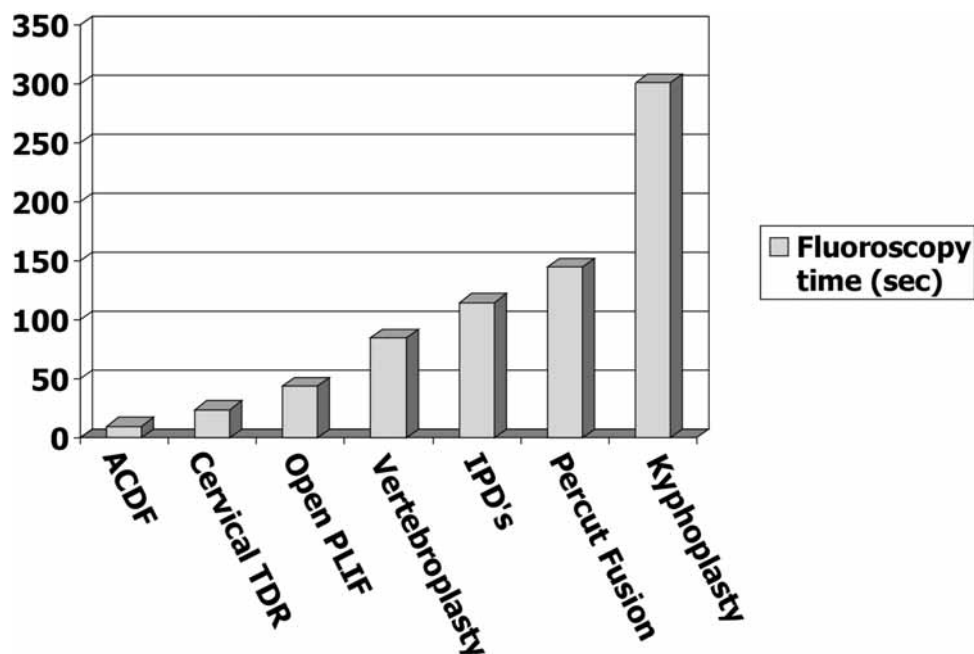
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*Fig. 1.* — Mean fluoroscopy time required by ACDF (Anterior Cervical Discectomy and Fusion) : 10.3 sec, cervical TDR (Total Disc Replacement) : 24.3 sec, open PLIF (PosteroLateral Interbody Fusion) : 44 sec, Vertebroplasty : 85 sec, Percutaneous IPD (Interspinous Process Device) : 115 sec, Percutaneous fusion : 145 sec, and Kyphoplasty : 301 sec.

## RESULTS

*Anterior Cervical Discectomy and Fusion* (Fig. 1) : the mean fluoroscopy time/operation was 10.3 sec, and the mean fluoroscopy time/level was 7.35 sec (cage alone : 8.3 sec ; cage + plate : 7.3 sec). The mean radiation dose/operation was 168.8 mGycm<sup>2</sup> or 119.5 mGycm<sup>2</sup> / level.

*Cervical Total Disc Replacement* : the mean fluoroscopy time/operation was 24.3 sec, and the mean fluoroscopy time/level was 24.3 sec. The mean radiation dose/operation was 455.6 mGycm<sup>2</sup> or 455.6 mGycm<sup>2</sup>/level.

*Vertebroplasty* : 8 levels were treated in 4 patients, either percutaneously or as an open procedure. The mean fluoroscopy time/operation was 1 min 25 sec or 43 sec/level. The mean radiation dose/operation was 6830 mGycm<sup>2</sup> or 3415 mGycm<sup>2</sup> /level.

*Kyphoplasty* : 18 fractured vertebrae were treated in 12 patients. Two C arms were used, respectively

for anteroposterior and lateral control. The fluoroscopy time/operation was 5 min 1 sec or 3 min 1 sec/level. The mean radiation dose/operation reached 14542 mGycm<sup>2</sup> or 9694 mGycm<sup>2</sup>/level. The mean anteroposterior radiation dose/level was 3907 mGycm<sup>2</sup>, and the mean lateral radiation dose/level 5751 mGycm<sup>2</sup>. Differences were observed between two similarly experienced surgeons : they needed respectively 2 min 37 sec/level and 5 min 13 sec/level.

*PosteroLateral Interbody Fusion (PLIF)* : 79 lumbar levels were treated in 30 patients, with 158 pedicular screws. The mean fluoroscopy time/operation was 44 sec or 16.8 sec/level and 8.4 sec/screw. The mean radiation dose/operation was 3983 mGycm<sup>2</sup>.

*Percutaneous lumbar fusion* : in 3 patients the pedicular screws were inserted percutaneously : 8 levels and 16 screws. Here the mean fluoroscopy time/operation was 2 min 25 sec or 55 sec/level, and the mean fluoroscopy time/screw 27 sec (com-

Table I. — Fluoroscopy time (sec)

ACDF	10,3
Cervical TDR	24,3
Open PLIF	44
Vertebroplasty	85
Percutaneous IPD's	115
Percutaneous fusion	145
Kyphoplasty	301

pared to 8.4 sec/screw for open PLIF). The mean radiation dose/operation was 9489 mGycm<sup>2</sup> (compared to 3983 for open PLIF) or 3558 mGycm<sup>2</sup>/level and 1779 mGycm<sup>2</sup>/screw.

*Percutaneous Interspinous Process Device* : 36 levels were treated in 20 patients with neurogenic intermittent claudication. Two C-arms were used simultaneously. The mean fluoroscopy time/operation was 1 min 55 sec or 1 min 4 sec/level. The mean anteroposterior fluoroscopy time was 35 sec/level, and the mean lateral fluoroscopy time 29 sec/level. The mean radiation dose/operation was 7512 mGycm<sup>2</sup> or 4173 mGycm<sup>2</sup>/level. Note-worthy : one surgeon needed 29 sec/level, whereas his colleague needed 83 sec/level, although both were equally experienced, used the same instruments and obtained similar results.

## DISCUSSION

### Exposure during cervical spine surgery

The radiation dose remained within acceptable limits. Using a cage alone or a cage with a plate did not significantly change the fluoroscopy time or the radiation dose per level. Total Disc Replacement increased the radiation time with a factor 2.7 and the total dose with a factor 2.8 when compared to classical fusion. This proportion may improve in the future as the more recent prostheses are easier to implant.

### Exposure during vertebroplasty and kyphoplasty

The data show that kyphoplasty involved high doses of radiation, particularly for the lateral view

at the lumbar level, where the fluoroscopy time was 3 times longer than for the anteroposterior control. This discrepancy did not exist at the thoracic level. These findings are similar to those of Boszczyk *et al* (1), who monitored 60 kyphoplasty patients reaching a mean fluoroscopy time of 3.8 minutes/level in single level operations and 2.8 minutes/level in multiple level operations. Ortiz *et al* (6) and Perisinakis *et al* (7) respectively reported a mean fluoroscopy time of 6.1 minutes and 10.1 minutes. This 1 to 2 ratio between surgeons, also observed in the current study, stresses the fact that the main variable may be the surgeon himself, at least for vertebroplasty and kyphoplasty. Two image amplifiers may help to reduce the fluoroscopy time by avoiding repetitive repositioning. Vertebroplasty seems to require less radiation than kyphoplasty, particularly if used in an open technique, probably because vertebroplasty avoids controlled balloon inflation.

### Exposure during pedicle screw insertion

Perisinakis *et al* (8) found an overall fluoroscopy time of 3.3 min and 7000 mGycm<sup>2</sup> per procedure. In the current study fluoroscopy time was only 44 sec per procedure and 8 sec per screw, probably because of technical expertise and because the technique did not require the use of anteroposterior views. The average radiation dose per screw was 3.2 times higher if inserted percutaneously.

### Exposure during insertion of percutaneous interspinous devices

Percutaneous interspinous process devices are a recent addition to the armamentarium of degenerative spine surgery. They are designed to treat the early stages of spinal stenosis in a minimally invasive way. These implants can be inserted percutaneously, under biplanar fluoroscopic control. Although this represents a minimal aggression to the lumbar spine, the amount of radiation delivered during these operations is by no means negligible. Again, a significant difference between surgeons was observed, with a 1 to 3 ratio.

### General factors influencing radiation dose

The *inferior positioning of the source* (4) in the anteroposterior view decreases radiation scattering to the surgeon. Of course, this limits the working space. But recent image amplifiers have a larger C-arm (1,7), so that the working space becomes more comfortable. In the lateral view, the source should be positioned with the radiation beam going away from the operator. Another factor influencing the radiation dose is the size of the patient (9).

The use of *computer assisted spinal navigation systems* may reduce the peroperative radiation dose (2). Up to now these techniques have been used mainly for pedicle screw placement, and their reliability has been questioned. Moreover, the need for landmarks registration and “reference star” placement makes them more difficult to use in purely percutaneous techniques. Also, the radiation dose required by preoperative computed tomography adds up to the peroperative fluoroscopy, which may diminish the advantages of this technique (10).

For vertebroplasty and kyphoplasty, using *modified cement delivery techniques and intermittent fluoroscopy* may also achieve a lower operator exposure rate (6).

### Risks for patient and surgeon ; protective measures

Valentin (12) reported that acute irradiation doses to *patients* may cause erythema at 2 Gy, cataract at 2 Gy, permanent epilation at 7 Gy and delayed skin necrosis at 12 Gy, putting forward the need for adequate surgeon training and patient information.

The risks of radiation exposure for the *surgeon* have been evaluated by Harstall *et al* (3) for vertebroplasty procedures. They found that the risks of developing skin or thyroid cancer and radiation induced cataract were low, but not negligible, and therefore advised radiation sparing surgical techniques and mandatory use of shielding devices. The surgeon’s hands are particularly at risk during pedicle screw insertion, and during vertebroplasty and kyphoplasty procedures. Wearing lead gloves

leads to a 75% reduction of radiation exposure and should be encouraged (11). Finally, Mroz *et al* (5) showed that during kyphoplasty procedures, the total radiation dose to the eyes and hands of the surgeon would exceed the occupational exposure limit after 300 cases per year.

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