Reduction of Radiation Exposure in Percutaneous Pedicle Screw Placement by Using a New Extension Instrument

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Study Design:

Experimental assessment of a method to reduce surgeon's radiation exposure by using an extension instrument during lumbar pedicle screw placement.

Objective:

To assess the reduction of radiation exposure to surgeons when using a new extension instrument (SurGenTec's ALARA radiation exposure reduction instrument).

Summary of Background Data:

Pedicle screw fixation is the gold standard for stabilization in spine surgery. Pedicle screw instrumentation may be performed using either a minimally invasive or open approach. Both techniques generally require the use of extensive fluoroscopy to help ensure the proper trajectory and placement of pedicle screws. There are many ways to dampen the radiation exposure including intraoperative navigation, intraoperative CT scan, and ultra-low radiation imaging. These methods reduce the overall radiation exposure but are not cost effective and there is a learning curve to become proficient with these techniques. In addition, many of these expensive devices and machines are constantly being improved, so technology can expire quickly and become obsolete.

Many surgeons attempt to reduce radiation exposure by using a Kocher clamp to keep further distance from the ionizing scatter radiation. Radiation exposure to medical staff has been a long-term concern when performing these procedures. Physicians can exceed their lifetime occupational radiation limit within the first decade of their career [1]. The main source of radiation exposure is the scatter radiation produced by the patient. Scatter radiation is higher in the proximity to the region of the patient getting the primary radiation beam. The surgeon's hands which are closer to the screw placement area generally receive the highest radiation exposure. High-dose or cumulative fluoroscopic x-ray radiation can cause DNA damage, hair loss, burns, and necrosis potentially causing the need for skin grafting [2]. While other sensitive tissues and organs such as the eyes, breasts, thyroid may also be affected, if in close proximity to the scatter radiation. Nearly half of all orthopedic procedures expose the physician to enough radiation to increase the risk of thyroid cancer [3]. By following ALARA (As low As Reasonably Achievable) recommendation, dose exposure should be reduced as much as possible. One simple

method is to extend the distance between surgeon's hands/body to the area exposed to the radiation beam.

The purpose of this study is to assess the reduction of dose exposure to surgeons at different proximities to the patient. This will be performed using the ALARA extension instrument developed by SurGenTec (Boca Raton, FL) and compared to an often used Kocher clamp. Both instruments may be used to increase the distance between the surgeon and radiation source. The data reduction of radiation exposure is compared for long term exposures of 1, 3, 5 and 10 years.

Methods:

Radiation exposure was produced by a C-arm GEMS OEC 9800. Source to imaging distance (SID) is 100 cm. The procedure was simulated by using a kVp of 85 kV and 3.6 mA. No magnification was used. The procedure was performed in posterior-anterior (PA) and lateral (LAT) positions. In position PA, the source to skin distance (SSD) was 42 cm and the x-ray tube was below the table. In the LAT position the SSD was 42 cm. Radiation scattering was simulated with 4 acrylic sheets of 15 cm x 15 cm and total thickness of 8 cm. Acrylic sheets were placed in the center of the table and field of view of the x-ray tube.

Radiation exposure was measured by using a calibrated RadCal ionization chamber model 10X6-180 (180 cc). Scattered radiation exposure was measured at four positions:

A) Center of acrylic sheets. (This is the position of the needle during the procedure).

B) Distance of 18 cm from the center of acrylic sheets. (This is the position of the Surgeon's hand at the Kocher clamp).

C) Distance of 46 cm from the center of acrylic sheets. (This is the position of the Surgeon's hand at the end of SurGenTec's radiation reduction instrument).

D) distance of 98 cm from the center of the acrylic sheets. (This is the position of the Surgeon's shoulder while grasping the end of SurGenTec's radiation reduction instrument. Radiation dose at this position could be considered as an approximation of the dose received by the thyroid gland and the lens of the eye).

A bilateral/single level lumbar spine fusion procedure requires 4 pedicle screws. According to three separate studies, the average fluoroscopy (radiation) time it would take to access one pedicle and insert one screw was 35.5 seconds [4-6]. Assuming half of that time would be used to access the pedicle and half would be used to insert the screw. It would take 17.75 seconds of radiation exposure time to access one pedicle. Thus, the radiation exposure time would be a total of 71 seconds to access four pedicles. Assuming each surgeon performs three bilateral/single level lumbar spine instrumented fusions procedures weekly at an average of 144 per year. The total radiation exposure at surgeon's hand position at 1, 3, 5 and 10 years was calculated.

Table I. Experimental setup

Radiation Machine	C-arm GEMS OEC 9800
kVp	85
mA	3.6
Fluoroscopy time (per procedure)	71 s
Scatter phantom	Acrylic block of 15 x 15 x 8 cm

Dosimetry results expressed in mSv are valid only for this Experimental setup.

Results

Radiation dose to surgeon's hand is higher in the LAT position X-ray tube-image receptor.

When using the SurGenTec extension instrument, the radiation dose is significantly reduced in both the PA and LAT positions.

In the PA position, SurGenTec extension instrument(c=46cm) reduces the dose of a surgeon's hand by approximately 15 times compared to using a Kocher clamp (b=18 cm).

The difference of dose between the position of the needle (d = 0) and the surgeon's hand in the SurGenTec extension instrument(c=46cm) is 293 times less radiation exposure.

Table II. Radiation dose. X ray tube-image receptor in PA position

Position	Dose per procedure (mSv)	Dose 1 year (mSv)	Dose 3 years (mSv)	Dose 5 years (mSv)	Dose 10 years (mSv)
A (d = 0)	0.778	112	336	560.0	1120.0
B (d=18 cm)	0.04	5.8	17.62	29.2	58.6
C (d = 46 cm)	0.002	0.38	1.14	1.92	3.82
D (d = 98 cm)	0.00048	0.070	0.210	0.35	0.70

A: Needle position; B: Surgeon's hand when using Kocher clamp; C: Surgeon's hand when using SurGenTec extension clamp; D: Surgeons shoulder while grasping the end of SurGenTec's radiation reduction instrument (this position is representative of dose to lens of the eye and thyroid gland).

Table III. Radiation dose. X -ray tube-image receptor in LAT position

Position	Dose per procedure (mSv)	Dose 1 year (mSv)	Dose 3 years (mSv)	Dose 5 years (mSv)	Dose 10 years (mSv)
A (d = 0)	0.072	10.5	31.4	52.4	105
B (d=18 cm)	0.044	6.42	19.42	32.2	64.2
C (d = 46 cm)	0.010	1.50	4.48	7.46	14.94
D (d = 98 cm)	0.004	0.62	1.84	3.1	6.2

A: Needle position; B: Surgeon's hand when using Kocher clamp; C: Surgeon's hand when using SurGenTec extension clamp; D: Surgeon's shoulder while grasping the end of SurGenTec's radiation reduction instrument (this position is representative of dose to lens of the eye and thyroid gland).

Conclusions

There is a significant reduction of ionizing radiation exposure when using the SurGenTec extension instrument versus tradition methods such as using a Kocher clamp for pedicle screw placement. The use of SurGenTec extension instrument will significantly decrease the radiation exposure to the surgeon's hands, eyes, thyroid, and the rest of their body when used properly.

When using the SurGenTec extension instrument in the PA position, 15 times more radiation exposure procedures can be performed to get the same hand's dose received when using the Kocher clamp. When using the SurGentec extension instrument there would be minimal radiation exposure to the body(thyroid gland, lens of eye, etc) due to the distance (98cm) between the radiation source and the surgeons body.

This SurGenTec extension instrument is a simple and cost effective option to reduce short term and long term radiation exposure during pedicle screw placement.

References

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