Radiation Scattering to the Primary Surgeon during Closed Locked Femoral Nailing

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A prospective study of the radiation exposure to the primary surgeon during closed static locked femoral nailing was performed in 50 cases. There were 44 males and 6 females whose ages ranged from 15 to 70 years (average, 32). The degree of fracture comminution was classified by Winquist. The cases included 1 Winquist (WQ)1, 9 WQ2, 27 WQ3 and 13 WQ4. The Grosse-Kempf femoral nail was used in 40 cases and the AO interlocking femoral nail was used in 10 cases. The C-arm image intensifier model Phillip BV212 and BV 300 were used during the present study. The average operation time was 52 minutes (range, 30 to 120). The fluoroscopic time for the entire procedure average 132 seconds (range, 23 to 366). The radiation exposure to the primary surgeon ranged from 2 to 231 micro-Sv with an average of 30 micro-Sv per procedure. From the present study, it was found that radiation scattered to the primary surgeon during current practice for closed static femoral nailing using the recent model of C-arm image intensifier was minimal and far below the permissible dose. It was also found that the group using the C-arm model BV 300 (n = 16) had significant lesser fluoroscopic time and less radiation scattering to the primary surgeon than the group with model BV 212 (n = 34).

Keywords: *Fracture, Femur, Radiation, Intramedullary nailing*

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There has been increasing use of image intensification or fluoroscopic control for several orthopaedic procedures such as closed intramedullary nailing of femoral and tibial fractures, fixation of proximal femoral fractures and minimal invasive osteosynthesis(1-4). Of several procedures that required fluoroscopic monitoring, closed locked femoral nailing has been reported to have a high amount of radiation scattered to the primary surgeon(3,5,6). Although there has been concern over the amount of scattered radiation to which the surgeon is exposed, most of the previous studies had included several orthopaedics procedures in the investigations(1-3,7,9). This made the results varied among series. With the improvement of the image intensification technology, the fluoroscopic time required for similar procedure such as closed femoral nailing in the recent reports(11-13) have been found shorter than those which had been reported earlier between 1980 and 1990(1,5,6,10). Because of the heterogeneity of the procedures being included in most reports and the old model of the image technology, the former reports of radiation exposure to the surgeon may not reflect the real current practice. The authors, therefore conducted the present study to quantify the amount of radiation scattering to the anterior neck region of the primary surgeon during closed static interlocking femoral nailing during current practice.

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Material and Method

The present study was performed as a prospective study at Siriraj Hospital between June 2000 and March 2004. The radiation dosage received at the anterior neck region of the primary surgeon who performed the closed static interlocking femoral nailing was measured. A digital pocket dosimeter model "Aloka PDM-107 for low energy X-ray type" with an accuracy of 1 micoSievert (micro-Sv) was used for the present study. The dosimeter was placed at the anterior neck region of the primary surgeon who performed the operation. The patient was operated on the fracture table with the traction via foot piece on the affected side and the contralateral side was in the hemilithotomy position on the special leg support. A C-arm image intensifier was positioned in between both legs with the radiation source placed below and the receiver above. For the lateral view, the C-arm was positioned of which the radiation source was at the lateral side and the receiver on the medial side of the operated limb. The surgeon performed closed interlocking nailing under image intensification as the ordinary technique for reamed femoral nailing procedure. The proximal locking was performed by using the proximal attachment targeting device. For distal locking, the procedure was performed by using a free-hand technique. Only one distal locking screw was used in most of the cases. Two distal locking screws were used only for the fracture which was located very distal from the level of one-forth of the femur. Two models of the C-arm image intensifier, Philip BV212 and Philip BV300, were used during the present study. The model of C-arm to be used depended on its availability at the time of surgery. The voltage and the electric energy being used were in automatic adjusting mode. The primary surgeon controlled the use of the fluoroscopy by foot control with pulse mode in all cases. The fluoroscopic time was automatically monitored by the image machine and was recorded from the beginning until the end of the operation. The operation time and the radiation dosage were recorded and the results were then analyzed.

Results

There were 50 cases of unilateral femoral fractures who underwent closed static locked femoral nailing and were included in the present study. Forty four patients were male and six were female whose ages ranged from 15 to 70 years (average, 32). Thirty cases had fractures were on the right and twenty on the left. Concerning the fracture comminution (Winquist classification, WQ)[14], there were one WQ1, 9 WQ2, 27 WQ3 and 13 WQ4. The Grosse-Kempf femoral nail was used in 40 cases and 10 cases in which the AO interlocking femoral nail was used. Only one static proximal locking was used in all cases. There were 46 cases using one distal locking screw and 4 cases using 2 distal locking screws. The operation time ranged from 30 to 120 minutes (average, 52 minutes). The mean fluoroscopic time was 132 seconds (range, 23 to 366). The mean radiation dose which scattered to the anterior neck region of the primary surgeon was 30 micro-Sv (range, 2 to 231) per procedure. The group with the C-arm model Philip 300 (n = 16) had an average fluoroscopic time and the dosage of radiation scattering of 55 seconds (range, 23 to 108) and 9 micro-Sv (range, 2 to 28) respectively. The average fluoroscopic time and radiation scattering in the group with Philip model 212 (n = 34) were 163 seconds (range, 61 to 366) and 40 micro-Sv (range, 3 to 231) (Table 1). The radiation exposure time and the radiation scattering to the primary surgeon in the group using BV300 were significantly less than the group using BV212 ($p < 0.05$).

Discussion

Little has been written about the risk to the orthopaedic surgeon during the use of C-arm image intensifier for closed femoral nailing. Dosch et al (1983) measured the relationship between radiation recorded in the operating room during interlocking intramedullary nailing and the distance of the radiation monitor from the patient. During seven minutes of fluoroscopy the dose of radiation was 170 micro-Sv when the distance was 40 cm, and 20 micro-Sv when the distance was 80 cm. Dosch et al also reported that the use of image memory mode decreased the duration of the fluoroscopy by 60 percent[13].

Miller et al[1] in 1983 measured the amount of radiation at 6 different anatomical sites during 7 different types of orthopaedic procedures that involved the use of fluoroscopy. They found that, although the standard lead apron provided adequate protection from the radiation, the greatest risk to the surgeon was in the area of the head, neck and hand. From their series, the average radiation exposure of the thyroid region was 290 micro-Sv during 6 intramedullary nailing and one plate osteosynthesis. The mean fluoroscopic time was 5.5 minutes per case.

Concerning fluoroscopic time, Kempf et al (1985) reported an average of 3.43 minutes per operation during 452 locked intramedullary nailing[15].

Table 1. Means of the fluoroscopic time and radiation dosage

C-arm	No. of cases	Fluoroscopic time (sec)	Radiation dosage (micro-Sv)
BV212	34	163 (sd = 72.8)	40 (sd = 41.9)
BV300	16	55 (sd = 22.1)	9 (sd = 8.1)
Total	50	131 (sd = 81)	30 (sd = 37.7)

Levin et al[5] in 1987 evaluated the exposure of the head and neck of the surgeon to radiation during 30 interlocking nailing (25 femoral and 5 tibial nailing). They found that a mean radiation exposure value of the neck region was 700 micro-Sv with a median fluoroscopic time of 8.01 minutes per operation.

Sugarman et al[10] in 1988 reported the radiation scattering to the neck region during closed AO femoral interlocking nailing in 10 cases. The average dose per operation was 440 micro-Sv.

Sander et al[3] found that the intramedullary nailing accounted for most of the positive reading for the radiation exposure in his series. It was found that nailing procedure that was associated with a positive result was done in the femur. He also found that the greatest level of radiation was recorded during the femoral nailing that involved distal locking.

From the present study, the mean fluoroscopic time per operation (132 seconds) was found less than that of previous reports (ranged from 3.43 to 24 minutes)[1,5,6,10]. This may be due to the fact that closed femoral nailing has become a familiar surgical procedure in current orthopaedic practice. The model of the image intensifier that the authors currently use can effectively adjust the amount of radiation with brief exposure and good quality of image display that can be retained on the screen. This can facilitate the surgeon to perform the operation faster and easier. The radiation scattering to the neck region was used for the present study because it has been reported that this area is prone to receive high radiation dosage during closed femoral nailing.

The results of the present study have shown that the radiation scattering to the region during closed locked femoral nailing was minimal with an average of 30 micro-Sv per operation. The amount of radiation dosage in the present study was found to be less than previous reports (range from 290 to 700 micro-Sv per operation)[1,5,10]. The dose limit for this area is 300 mSv per year, as recommended by the international Commission on radiological Protection[16]. Extrapolation of the mean dose of the primary surgeon per procedure of 30 micro-Sv leads to the result that the recommended dose limit of 300 mSv would only be exceeded if more than 10,000 operations are carried out per year.

Different models of C-arm image intensifier (Philip BV212 vs BV300) have been found to have different fluoroscopic times and radiation dosage to the primary surgeon per operation. This may be due to the fact that the model BV212 used in the present study was older and had been used more than 4 years before the model BV300 could be available in our service. The authors also observed that when using an equal number of shooting for fluoroscopy in the pulse mode, the fluoroscopic time required for BV212 was always longer than that of BV300. This may be due to the internal quality of the equipment of each model.

In conclusion, the present study has shown that the radiation scattering to the primary surgeon measured at the thyroid area during closed locked femoral nailing is very minimal and far below the safety limit. Using different models of C-arm image intensifier may cause significant difference of the fluoroscopic time and radiation dosage to the primary surgeon during such a procedure.

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การสัมผัสรังสีของศัลยแพทย์ระหว่างการสอดแกนดามยึดตรึงกระดูกต้นขาหักแบบไม่เปิดรอยหัก

บรรจง มไหสวริยะ, ภานุพันธ์ ทรงเจริญ, ก้องเขต เหรียญสุวรรณ

ผู้รายงานได้ทำการศึกษาปริมาณรังสีที่ศัลยแพทย์สัมผัสระหว่างการผ่าตัดสอดแกนดามยึดตรึงกระดูกต้นขาหักแบบใส่สกรูล็อคทั้งสองปลายโดยไม่เปิดรอยหักในผู้ป่วยจำนวน 50 ราย เป็นผู้ป่วยชาย 44 ราย ผู้ป่วยหญิง 6ราย อายุเฉลี่ย 32 ปี (พิสัย 15-70) รอยหักมีลักษณะแตกเป็นชิ้นย่อยตามการแบ่งของ Wirquist (WQ) แบบ WQ1 1 ราย, WQ2 9 ราย, WQ3 27 ราย และ WQ4 13 ราย ผู้ป่วย 40 รายได้รับการยึดตรึงโดยใช้แกนดามชนิด Gross-Kempf และ 10 รายใช้แกนดามชนิด AO Interlocking Femoral Nail โดยใช้เครื่องฉายรังสีแบบปรากฏภาพบนจอ (C-arm image intensifier) รุ่น Philip BV 212 ในผู้ป่วย 34 ราย และรุ่น BV 300 ในผู้ป่วย 16 ราย ระยะการผ่าตัดเฉลี่ย 52 นาที (พิสัย, 30-120) พบระยะการใช้รังสีตลอดการผ่าตัดเฉลี่ย 132 วินาที (พิสัย, 23-366) ต่อการผ่าตัด 1 ราย และการสัมผัสรังสีของศัลยแพทย์วัดที่ตำแหน่งด้านหน้าของคอระดับต่อมไทรอยด์ เฉลี่ย 30 ไมโครซิเวอร์ท (พิสัย, 2-231) ต่อการผ่าตัด 1 ราย พบการใช้รังสีในกลุ่มที่ใช้ C-arm image intensifier รุ่น BV 300 มีระยะเวลาสั้นกว่า และศัลยแพทย์สัมผัสรังสีน้อยกว่ากลุ่มที่ใช้เครื่อง C-arm image intensifier รุ่น BV 212
