HAND DOSE LEVELS IN FLUORO-CT GUIDED PROCEDURES – USE OF A NEEDLE HOLDER

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Abstract

In this work the dose received by the dominant hand of the interventional radiologist was assessed during fluoro CT guided procedures while using a needle holder. The results show that the needle holder significantly reduced the per procedure dose levels and hence the total accumulated dose. The measurements were performed with thermoluminescence extremity dosemeters inserted in special gloves prepared in-house. $H_p(0.07)$ on the five finger tips and bases of the dominant hand was measured. Although the dose values show a large variation, in general, the middle, ring and little fingers are the most exposed. Maximum dose values per procedure in the range 5.7 to 8.1 mSv were obtained. The base of thumb and little fingers are the less exposed with a maximum dose value around 1 mSv. The values are nearly 10 times lower compared with previous results where this tool was not considered. One

concludes that the use of needle holders is strongly recommended in order to increase the distance between the hand and the primary beam and hence reducing the dose received by the dominant hand.

1. INTRODUCTION

Optimizing individual monitoring in CTF-guided procedures requires a reasonable understanding of the typical dose distributions which may be difficult to attain as they are very different from those of conventional fluoroscopy. High radiation dose to the radiologist´s hands is expected [1] Earlier papers report that the dose to the radiologist's hands in the direct beam could reach 120 mSv per procedure [2]. Since the hands of the IR are very close to the imaging/radiation plane, high hand exposures are expected. The use of biopsy needle holders may reduce the dose to the hand by increasing the distance to the scan plane [3, 4, 5] although this tool may decrease tactile feedback and may lead to longer fluoroscopy times [6]. The results presented by Stoeckelhuber shown that a long needle holder decreased the dose rates by 30% [6]. Opinions differ regarding how easy it is to use needle holders. Some authors report no difficulty [2, 3], while others argue that needle holders decrease tactile feedback and grip [4, 7, 8]. Dedicated needle holders have been developed [2, 3, 6, 9] but many authors prefer metallic sponge forceps or towel clamps due to their widespread availability, lightweight, strength, ease of sterilization and relatively low cost [4, 5, 7].

The aim of this work is to characterize the dose distribution to the dominant hand of the interventional radiologist (IR) in CTF-guided biopsies with the use of a needle holder to increase the distance to the radiation plane in real-life clinical conditions. Per procedure dose values to the dominant hand were obtained during 34 procedures when needle holders was used, in conditions as similar as possible to those of previous measurements where the needle was directly gripped [10-12] (same radiologist, CT-scanner, type of procedures, method of random sample selection and sample size) to allow for the comparison of results.

2. MATERIAL AND METHODS

CTF procedures were all performed at IPO-Porto by a single experienced interventional radiologist. The CT-scanner was a Toshiba Asteion 4-slice with the following parameters: tube voltage of 120 kV, current 40 mA or 50mA, rotation of 0.75s and 8mm of beam collimation. The typical biopsy procedure has been described in detail elsewhere [13]. The intermittent imaging method proposed by Silverman is always used, so that the hands of the interventionist are kept away from the beam during irradiation [7]. However, in some situations the quick-check method is combined with periods of needle manipulation during real-time imaging and irradiation. To prevent direct irradiation of the hand, an improvised needle holder (towel clamp) was used. This technique is different to that previously reported, where the needle was held by the side handle [13].

For the assessment of the dose to the hands, thin plastic gloves were developed in-house with special casings for the insertion of high-sensitivity thermoluminescence extremity detectors used on a per procedure basis [10]. A total of 10 detectors of LiF:Mg,Cu,P (TLD-100H) of the EXT-RAD type were placed on the casings at the tip and base of all fingers as shown in Fig. 1. A sterylized glove was used on top. The dosemeters were calibrated in terms of $H_p(0.07)$ at the Secondary Standard Dosimetry Laboratory of IST-LPSR using a N120 X-ray beam incident on a ISO rod phantom. The readouts were performed on a Harshaw 6600 reader using predefined cycles, the day after irradiations [10]. In this case study, the hand dose assessment was performed in 34 biopsy procedures where CTF-guidance was necessary, mainly to the lungs (27), but also abdomen (5) and bone (2).

FIG. 1. Dominant hand with ten extremity dosemeters placed at the tip and base of each finger

3. RESULTS AND DISCUSSION

Fig. 2 shows the distribution of per procedure $H_p(0.07)$ dose measurements organized by dose intervals. Almost all procedures showed dose levels below 1 mSv, particularly in the case of the detectors placed at the base of the fingers. The detectors placed on the tip showed a higher variation, althought more than 80% of the values are also below 1mSv.

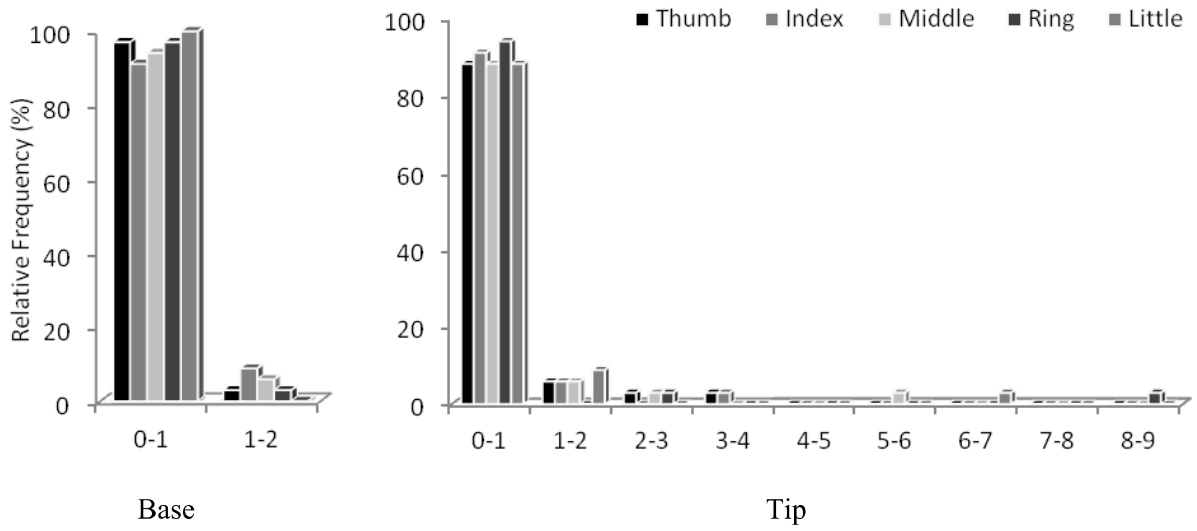

FIG. 2. Distribution of the per procedure $H_p(0.07)$ values measured on the base (left) and tip (right) of each finger organized by dose intervals (in mSv).

The maximum and mean (per procedure) dose values obtained on the tip and base of each finger are presented in Table I. It can be observed that the dose levels received on the tip of the fingers is higher than on the base. The tip of the middle, ring and little fingers are the most exposed regions with maximum values of 5.68, 8.09 and 6.05 mSv, respectively. The results also show that the base of thumb and little fingers are the less exposed regions with mean values of 0.23 and 0.33 mSv and maximum values of 1.09 mSv and 0.99 mSv, respectively.

TABLE I. MAXIMUM AND MEAN $H_P(0.07)$ VALUES (PER PROCEDURE) MEASURED AT THE TIP AND BASE OF EACH FINGER, EXPRESSED IN mSv (ALL 34 PROCEDURES CONSIDERED)

	Thumb		Index		Middle		Ring		Little	
	Tip	Base	Tip	Base	Tip	Base	Tip	Base	Tip	Base
Maximum	3.89	1.09	3.10	1.25	5.68	1.28	8.09	1.09	6.05	0.99
Mean	0.51	0.23	0.49	0.37	0.55	0.39	0.57	0.36	0.53	0.33

The total accumulated dose integrated in the 34 CTF procedures in all measurement positions is shown in Table II. The results obtained in previous work without the use of the needle holder [12] are also included for comparison. A higher number of procedures was analised in Ref. [12], however, the results presented herein were interpolated so that both situations could be compared. The results obtained when the needle holder is used show that in general the tip of the fingers is more exposed than the base. This statement is valid in both situations, with and without the use of the needle holder. When the needle holder is used, the dose values at finger tips are very similar in the range 17-19 mSv. Taking into account the annual dose limit to the extremities of 500 mSv the results suggest the IR could perform approx. 850 procedures every year.

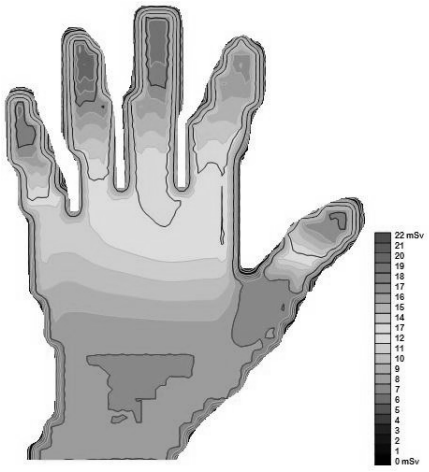

FIG. 3. Total dose to the dominant hand of the IR considering all 34 procedures. (colour grading to guide the eye).

TABLE 2. INTEGRATED $H_P(0.07)$ TO THE TIP AND BASE OF EACH FINGER: WITH NEEDLE HOLDER (THIS WORK) AND WITHOUT [12]

	Tip		Base	
Finger	With (this work)	Without [12]	With (this work)	Without [12]
Thumb	17,3	118	7,8	26
Index	16,7	186	12,6	89
Middle	18,7	179	13,3	101
Ring	19,4	216	12,2	87
Little	18,0	133	11,2	71

Compared with previous results [10-12] obtained by this team and particularly in Ref. [12] the use of the needle holder significatly reduced the dose levels on the hands of the IR, almost by a factor of 10. Whithout the needle holder the dose to the tips is much higher than the dose to the base, in some cases by a factor of 2; the tip of the index, middle and ring fingers is also more exposed than the thumb and little fingers.

With the needle holder tool, the number of procedures with $H_p(0.07)$ values below 1 mSv increased and the maximum dose values considerably decreased. The dose values to the tips is again higher that the dose to the base, but all five fingers are more homogeneously irradiated and at the same time the difference between the dose to the tips and to the bases is not so large.

4. CONCLUSIONS

In this work the dose received by the IR on the dominant hand was studied in 34 CTF-guided procedures with the use of a needle holder. The results obtained suggests a significant dose redution on the exposure to the hand of the IR, highlighting the importance of using needle holders as a protective tool for optimization of radiological protection in CTF procedures. On the other hand, when the needle holder is used the similarity of the dose values on all fingers, irrespective of the position (tip or base) minimizes the uncertainty on the selection of the dosemeter position.

In the absence of the needle holder tool the results suggest that the dosemeter should be worn on the tip of the index, middle or ring fingers. But if the needle holder is used the usual (and comfortable) ring type dosemeter can be safely used.

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