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ARTICLE

Radiographers' attitudes toward the principles of patient radiation protection in the Souss Massa region of Morocco

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Abstract – Introduction: Radiographers play a vital role in patient radiation protection. Their training, supervision, and involvement in radiation protection programmes require greater attention from all stakeholders. Methods: This cross-sectional study was conducted between March and August 2023 to assess Radiographers' attitudes toward the principles of patient radiation protection in the Souss Massa region of Morocco. An anonymous questionnaire containing 22 questions was sent to 80 radiographers practicing in the Sous Massa region. Results: 67.5% of the radiographers confirmed that they did not use a guide to radiological procedures. 85% of them confirmed that they had checked for the possibility of pregnancy each time a woman of childbearing age was involved in a conventional X-ray, compared with 97.5% who checked for the possibility of pregnancy in a CT scan. 97.5 % of our participants said that they automatically (without medical advice) repeated the X-ray examination if the image was not interpretable. 90% of radiographers said that they did not report parameters for dose estimation for each conventional X-ray examination, and 72.5% did not report data for dose estimation for CT-scan examinations. The results showed no association between gender and professional experience on the one hand and radiographers' practices on the other. Nevertheless, there is an association between the workplace and certain radiographers' practices, indicating the lack of a regional strategy aimed at standardizing procedures and radiation protection practices at the level of all radiology departments. Conclusion: It is vital to launch a patient dose management program in the Souss Massa region and campaigns to raise radiographers' awareness of recommended patient radiation protection practices.

Keywords: Radiation protection / radiation dose / computed tomography / radiography / safety standard

1 Introduction

Ionising radiation has many beneficial applications in a number of fields, including medical diagnosis. However, the risks associated with its use must be assessed and, if necessary, controlled (IAEA, 2014).

Medical exposure to ionizing radiation represents the largest contribution to population dose from artificial sources, and diagnostic X-rays make up the majority of this contribution (approximately 90%) due to the increasing number of X-ray examinations carried out each year (IAEA, 2007).

In addition, direct epidemiological evidence has been demonstrated linking exposure to ionising radiation to the risk of radiation-induced cancer (ICRP, 1999). In this context, the results of the Life Span Study (1950–1990) showed that 334 of the 7,578 people who died of solid tumours could be attributed to exposure to ionising radiation (United Nation, 2000).

This situation demonstrates the importance of justification and optimisation as two essential principles of radiological protection in medical imaging. The principle of justification means that the individual or societal benefit resulting from medical exposure to ionising radiation must be sufficient to compensate for the harm caused. The principle of optimisation means that individual doses of exposure must be kept as low as reasonably achievable, considering economic and societal factors (ICRP, 2007).

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The application of the optimisation principle calls for collaboration between radiologists, medical physicists and radiographers, each of whom contributes to specific aspects of the imaging process (ICRP, 2017). In this context, radiographers are a key player in assuring the commitment toward the three principles of radiation protection, as recommended by the International Commission of Radiation Protection (Paulo, 2020).

Given the responsibilities they hold in the process of producing medical imaging, radiographers are called upon to master the operation of the equipment and software, as well as their implications for the radiation protection of their patients. Ongoing training is required whenever new equipment or software is installed and when significant changes are made (IAEA, 2018).

In Morocco, radiographers undergo a specific education and training program in diagnostic radiology, radiotherapy, and nuclear medicine, spread over 3 years of study (6 semesters). This training culminates in the award of a bachelor's degree in health techniques, specialising in radiology. These healthcare professionals are directly involved in optimising the doses delivered to patients in conventional radiology and CT. They require appropriate basic training and periodic ongoing training, particularly in patient radiation protection. In this context, this study assessed radiographers' attitudes toward the principles of patient radiation protection in the Souss Massa region of Morocco.

2 Materials and methods

2.1 Study population

This cross-sectional study was conducted between March and August 2023, involving all radiographers from six public hospitals in the Souss Massa region of Morocco. Of the 85 radiographers working in the region's public sector, 80 accepted to participate in the study (94% participation), including five radiographers who took part in the questionnaire validation stage.

2.2 Questionnaire

An online questionnaire comprising 3 sections and 22 questions was drawn up with reference to the literature (ESR, 2015; ASN, 2016).

The first section focused on the demographic characteristics of the participants, such as gender, age, professional experience, education level and worksite. The second part consisted of 20 questions relating to the principles of justification and optimisation: knowledge of justification procedures, use of the radiological procedures guide, performing X-ray examinations with and without an examination voucher, importance of clinical indications, dealing with X-ray examinations that have to be repeated, use of protocol guides for each CT examination, adaptation of exposure parameters (kV, mAs), transcription of dosimetric data, treatment of women of childbearing age and optimisation in pediatric radiology. The third section was devoted to the question of whether or not our participants had received basic and ongoing training in radiation protection.

2.3 Questionnaire reliability and validity

The Cronbach's alpha value for our measurement scale is 0.734, which indicates acceptable reliability of the scale for measuring the internal consistency of its components.

Construct validity was assessed using Pearson's correlation test to evaluate the relationship between the questionnaire items. The results indicate that the majority of items are significantly and positively correlated with each other. However, some items showed only a weak correlation, which may require future revision to strengthen the validity of the questionnaire.

Before being sent to the participants, the questionnaire was distributed to a group of 5 radiographers to test the clarity of the questions. Some questions were reworded considering the comments made during this stage.

2.4 Statistical analysis

Fisher's exact statistical test was used to establish the relationship between the categorical variables, namely gender, professional experience, place of work, and radiographers' practices. The relationship is significant if the p-value is less than 5%.

2.5 Ethical approval

This study received ethical approval from the ethics committee for biomedical research, Mohammed V University of Rabat, under protocol number 28/22.

Participants were informed of the objectives of the research, the data collection process, and the confidentiality of their answers. To obtain informed consent, a tick box entitled 'I agree to take part in this survey' was provided on the first page of the online questionnaire.

3 Results

3.1 Socio-professional characteristics of the study population

A total of 80 questionnaires were received and analysed out of 85 sent to participants, with a response rate of 94%. Table 1 presents the sociodemographic data of the participants. The population of our study is made up of 65% women and 35% men. Of the participants, 97.5% are under 35 years old. 95% of the participants have less than 10 years of professional experience. In terms of level of education, most participants (92.5%) had a bachelor's degree, with the remainder (7.5%) having a master's degree. The participants of this study worked at six public hospitals in the Souss Massa region: H1 (32.5%), H2 (11.25%), H3 (12.5%), H4 (18.75%), H5 (15%), and H6 (10%).

3.2 Application of the principles of justification and optimisation in conventional radiology and CT

Table 2 summarizes the radiographers' answers to this study regarding their radiation protection attitudes.

65% of our participants stated that they are aware of the procedures for the justification of radiographic examinations.

Table 1. Demographic data of radiographers who participated in this study

		Participants	Percentage %
Sex	M	28	35
	F	52	65
Age	Under 25 years	26	32.5
	25–35 years	52	65
	35–45 years	2	2.5
	Over 45 years	0	0
Years of professional experience	5–10 years	30	37.5
	11–15 years	4	5
	Over 15 years	0	0
Worksite	H1	26.00	32.5
	H2	9.00	11.25
	H3	10.00	12.5
	H4	15.00	18.75
	H5	12.00	15
	H6	8.00	10
Education level	Bachelor's degree	74	92.5
	Master's degree	6	7.5

67.5% confirmed that they do not use a guide to radiological procedures, including written procedures for the most common radiological examinations and recommendations for reducing radiation doses. 90% comply with the administrative procedure for performing radiological examinations, in particular the requirement for an examination form (examination voucher) listing exactly the examinations to be performed and the clinical indications. 97.5% of our participants said that they automatically (without medical advice) repeat the X-ray examination if the image is not interpretable.

The results show that 85% of our participants confirmed that they had checked for the possibility of pregnancy each time a woman of childbearing age was involved in a conventional X-ray, compared with 97.5% who checked for the possibility of pregnancy in a CT-scan. In addition, 90% of radiographers said that they do not report parameters for dose estimation (mAs, kV, FFD, field size, number of examinations) for each conventional X-ray examination, and 72.5% do not report data for dose estimation for CT-scan examinations, such as the dose length product (DLP) and the computed tomography dose index (CTDI).

Regarding the adaptation of acquisition parameters to the patient's age and morphology, 90% of radiographers say they always adjust acquisition parameters in conventional radiology, compared with 42.5% in CT-scan examinations. Concerning the radiation protection of children in conventional radiology, only 37.5% of our participants stated that they use radiation protection equipment appropriate to the age of the child (thyroid shield, gonad shield, etc.). For CT, only 5% of our radiographers consult the reference levels in terms of PDL and CTDI before each new acquisition.

4 Discussion

The population in our study was very young, with 97.5% aged under 35 years, and 95% of the participants had less than 10 years of professional experience. In addition, 92.5% of the participants had a bachelor's degree. This situation reflects the new recruitment policy of the Moroccan Ministry of Health, with the adoption of regional recruitment and the promotion of basic training for health professionals, particularly radiographers. It turns out that young radiographers with less than 3 years of experience showed a higher level of knowledge than the more experienced radiographers (Paolicchi *et al.*, 2016).

The results of our study show that 65% of radiographers stated that they were aware of the procedures for justifying and optimising radiographic examinations, and 35% were unaware of these procedures. In addition, statistical analysis showed that of the participants who said they were aware of the justification and optimisation procedures, 46% said they added additional radiological examinations without medical advice, and 96% of them tended to automatically repeat each radiological image treated as defective, while only 46% reported the number of examinations repeated. Furthermore, 92% of radiographers who were aware of radiation protection procedures did not report the dosimetric information needed to calculate the doses received by patients. In addition, 57% of radiographers do not use radiation protection equipment adapted to the age and morphology of children. This analysis shows that radiographers' knowledge of patient radiation protection does not match their attitudes and practices, which justifies the importance of carrying out this study. This result is in agreement with a previous study conducted in Egypt, which revealed that although 51.3% of the staff working in the radiology department were aware of radiation protection procedures, 82% of them did not have practical knowledge on the use of radiation safety measures (Salah Eldeen, 2020).

In fact, Radiographers' ignorance of certain aspects of radiation protection can lead to unnecessary increases in radiation doses delivered to the patient (Paolicchi *et al.*, 2016). In this context, several previous studies assessing the doses received by patients and establishing local DRLs in the Souss

Table 2. Radiographers' answers according to the question (the percentage is between brackets and the significant *p* values is in bold).

Questions	Proposals	Answers	P-value		
			Gender	professional experience	Worksite
Q1. Are you aware of the procedures for the justification and optimisation of radiographic examinations?	Yes No	52 (65) 28 (35)	0.501	0.109	0.843
Q2. Do you use a guide to radiological procedures, including written procedures for the most common radiological examinations and recommendations for reducing radiation doses?	Yes No	26 (32.5) 54 (67.5)	0.316	0.644	0.866
Q3. Do you perform radiographic examinations without prior exchange of written information (examination voucher)?	Yes No	8 (10.0) 72 (90,0)	0.602	0.124	0.362
Q4. Do you add more radiological examinations to the examination requested when you consider them useful for diagnosis?	Always Often Sometimes Never	10 (12.5) 32 (40.0) 32 (40.0) 6 (7.5)	0.151	0.851	0.743
Q5. Do the radiographic examination forms you receive indicate the reason for, and the purpose and circumstances of, the examination?	Always Often Sometimes Never	2 (2.5) 16 (20.0) 52 (65.0) 10 (12.5)	0.702	0.887	0.372
Q6. Indicate the circumstances in which you would repeat an X-ray examination without medical advice?	when you receive a written request from the prescribing doctor	48 (60)	0.524	0.145	0.451
	If the image taken does not meet all the success criteria indicated using the radiological procedure	44 (55)	0.446	0.308	0.345
	If the image is a failure (cropped, overexposed or underexposed), I will automatically repeat the examination.	78 (97.5)	0.650	0.685	0.831
Q7. Do you indicate the number of repeat radiographic examinations in the patient registers?	Always Often Sometimes Never	28 (35.0) 12 (15.0) 8 (10.0) 32 (40.0)	0.139	0.820	**0.001**
Q8. Do you have a protocol for each CT procedure performed near the radiology equipment?	Yes No	30 (37.5) 50 (62.5)			0.573
Q9. In conventional radiography, do you ask about a possible pregnancy whenever a woman of childbearing age is involved?	Always Often Sometimes	68 (85.0) 10 (12.5) 2 (2.5)	0.139	0.898	0.199
Q10. In conventional radiography, do you adjust the acquisition parameters (kV, mAs) according to the patient's age and build?	Always Often	74 (92.5) 6 (7.5)	0.724	0.371	0.175
Q11. In conventional radiography, do you report information on dose estimates (PDS, mAs, kV, FFD, field size, number of examinations) for each radiographic examination?	Yes No	8 (10.0) 72 (90.0)	0.562	0.207	**0.002**
Q12. In conventional radiography, do you record the patients' ages and weight?	Yes No	12 (15.0) 68 (85.0)	0.646	0.758	0.440

Table 2. (continued).

Questions	Proposals	Answers	P-value		
			Gender	**professional experience**	**Worksite**
Q13. In CT-scan, do you have a written protocol for each CT-scan protocol?	Yes No	36 (45.0) 44 (55.0)			**0.013**
Q14. In CT-scan, do you ask about a possible pregnancy whenever a woman of childbearing age is involved?	Yes No	78 (97.5) 2 (2.5)	0.350	0.685	0.150
Q15. Do you adapt CT-scan protocols according to the patient's age and weight?	Always Often Sometimes Never	38 (47.5) 18 (22.5) 12 (15.0) 12 (15.0)	0.357	0.454	**0.001**
Q16. In CT-scan, do you adapt the acquisition parameters (kV, mAs) to the patient's morphology?	Always Often Sometimes Never	34 (42.5) 10 (12.5) 24 (30.0) 12 (15.0)	0.395	0.127	**0.001**
Q17. Do you systematically check the value of the computed tomography dose index (CTDI) before starting the acquisition?	Always Often Sometimes Never	8 (10.0) 12 (15.0) 14 (17.5) 26 (57.5)	0.803	0.431	0.662
Q18. Do you report information about the dose estimate for CT-scan examinations, such as the dose length product DLP and the computed tomography dose index CTDI, on the register or in another medium?	Always Often Sometimes Never	4 (5.0) 4 (5.0) 14 (17.5) 58 (72.5)	0.802	0.577	0.395
Q19. Select your attitude towards dose optimisation in pediatric conventional radiology from the following choices:	I choose the exposure parameters (kV, mAs) according to the child's age and weight	80 (100)			
	I use manual and luminous centring, and avoid fluoroscopy	56 (70)	0.885	**0.011**	0.155
	I limit X-ray exposure to the area to be examined	76 (95)	0.533	0.899	0.279
	I minimise the number of X-ray images taken	64 (92.5)	0.137	0.894	0.543
	I use radiation protection equipment appropriate to the age of the child (thyroid and gonad shield)	30 (37.5)	0.736	**0.035**	0.249
Q20. Select your attitude towards dose optimisation in pediatric CT-scan from the following choices	I use age-appropriate restraints	54 (67.5)	0.316	0.542	0.774
	I adjust the exposure parameters according to the child's age, weight and height	54 (67.5)	0.316	0.644	0.472
	I use specific pediatric CT-scan protocols	56 (70)	0.885	**0.011**	0.776
	I limit the volume to be irradiated	72 (90)	0.658	0.725	0.856
	I consult the reference levels in terms of PDL and CTDI before each new acquisition	4 (5)	0.648	0.899	0.750
Q21. Have you received basic training in patient radiation protection?	Yes No	74 (92.5) 6 (7.5)	0.186	0.062	0.769
Q22. Have you received ongoing training in patient radiation protection?	Yes No	4 (5.0) 76 (95.0)	0.287	0.459	**0.033**

Massa region have revealed alarming dose levels for several conventional radiological examinations (El Fahssi *et al.*, 2023) and CT scan protocols (Semghouli *et al.*, 2022, 2024a).

One possible reason for the lack of knowledge about patient radiation protection among radiographers is that radiation protection courses are rarely offered in universities (Aldhafeeri, 2020). In fact, only one radiation protection course is given to students during their training at Morocco's nursing and technical health institutes, which are responsible for training most radiographers working in the public sector.

Training institutes should reinforce their curricula with theoretical and practical courses relating to patient radiation protection, particularly in terms of reducing radiation doses and image quality (Semghouli *et al.*, 2022). Although the delivery of radiation doses is the responsibility of radiographers, they should improve their knowledge of radiation dose levels. Therefore, education is the best way to improve awareness of the potential risks of ionizing radiation (Aldhafeeri, 2020; MirDerikvand *et al.*, 2023).

In addition, a positive correlation between knowledge and attitudes of radiographers was statistically validated, and radiation safety training was identified as a significant factor affecting these attitudes (Alomairy, 2024).

Institutional factors can also explain the gap raised by this study between radiographers' declarations and their actual practices, in particular the absence of establishment of quality assurance programs in medical imaging departments, the absence of audit aimed at identifying practices hindering the proper protection of patients against ionizing radiation, and the absence of the medical physicist responsible for the optimization process in the majority of hospitals in the Souss Massa region. Optimization of radiation doses while maintaining good image quality for reliable diagnosis can be achieved by improving the knowledge of radiographers and radiologists regarding radiation protection, justification, and optimization of protocols through rigorous audits of hospital radiation at the national level (Semghouli *et al.*, 2024b).

67.5% of our radiographers confirmed that they do not use a guide to radiological procedures, including written procedures for the most common radiological examinations and recommendations for reducing radiation doses. However, a guide of radiological procedures and others for regular quality control of radiological equipment are needed to optimize diagnostic procedures and prevent adverse events (Amaoui *et al.*, 2023). In this framework, guides to radiological procedures, such as those produced by the French Society of Radiology (SFR), help to apply the principle of optimisation by providing written procedures for the most common radiological examinations in conventional radiology, CT scan, interventional radiology and paediatric radiology, as well as indication of diagnostic reference levels for the most common examinations and recommendations for reducing radiation doses (ASN, 2011). Furthermore, Council Directive 2013/59/Euratom of December 5, 2013, laying down basic safety standards for health protection against the dangers arising from exposure to ionising radiation, states that written protocols for every type of standard medical radiological procedure must be established for each equipment for relevant categories of patients (ESR, 2015).

The results show that 40% of the population studied often add additional radiological examinations to the examination requested when they consider them useful to the diagnosis, 40% sometimes do so, and 12.5% always do so. Only 7.5% of the participants stated that they did not add any examinations to the examination requested. In addition, 97.5% of our participants said that they automatically, without medical advice, repeat the X-ray examination if the image is a failure (image not interpretable), and 55% repeat it if they consider that the image taken does not meet all the success criteria indicated by the radiological procedure. This result shows that repeat radiological examinations are common practice among our participants, unlike the radiographers who took part in a similar study in Ghana, who confirmed that they did not repeat radiological examinations always/most of the time (Fiagbedzi, 2022). In fact, repeated radiological examinations due to poor image quality result in unnecessary patient exposure to ionizing radiation, possible loss of diagnostic information, and increased economic costs of health care (Muhogora *et al.*, 2008).

85% of our participants confirmed that they had checked for the possibility of pregnancy each time a woman of childbearing age was involved in a conventional X-ray, compared with 97.5 who checked for the possibility of pregnancy in a CT scan. This result is satisfactory when compared with the study performed by Fiagbedzi *et al.*, which showed that 37.5% of radiographers found that it was not encouraging to ask patients about their pregnancy status before radiological examinations and that over thirty percent were not asked frequently (Fiagbedzi *et al.*, 2022). Before any exposure to ionising radiation, it is important to determine whether a female is or could be pregnant because for some patients, the exposure may be inappropriate, placing the embryo/foetus at increased risk (ICRP, 2007). Raising awareness among radiographers and the public and introducing visual aids in the departments explaining the risks of radiation exposure to pregnant women in the local language could improve this result.

On estimating patient doses, 90% of radiographers said that they do not report information on dose estimate (mAs, kV, FFD, field size, number of examinations) for each conventional X-ray examination, and 72.5% of them do not report information about the dose estimate for CT-scan examinations such as DLP and CTDI. This result is similar to that of a previous study conducted at the Souss Massa Regional Hospital, where only 10% of radiographers reported information regarding dose estimation during imaging (Semghouli *et al.*, 2015). However, the exposure parameters and the resultant patient doses should be standardised, displayed and recorded (ICRP, 2017). Directive 2013/59/Euratom also confirms that information on patient exposure must be included in the report on the medical radiological procedure (ESR, 2015).

Regarding the adaptation of acquisition parameters to the patient's age and morphology, 90% of radiographers say they always adjust acquisition parameters in conventional radiology, compared with 42.5% in CT-scans. Normally, image acquisition parameters change with the anatomy of the patient, such as size, age group, and gender (Manmadhachary *et al.*, 2017). In fact, the non-standardization of acquisition parameters in hospitals in the Souss Massa region leads to variability in practices and a dispersion of the dose delivered to patients (El Fahssi *et al.*, 2023). In CT, radiographers tend to use standard protocols for each examination without adjusting the acquisition parameters according to the patient's age and build, which justifies the percentage of 42.5% quoted above. In fact, a recent study in the same region analysing data from six different CT scans showed the use of standard pre-established protocols and the lack of adjustment of these protocols to the morphology of the patients and the conditions of the examination (El Fahssi *et al.*, 2024).

Concerning the radiation protection of children in conventional radiology, only 37.5% of our participants stated that they use radiation protection equipment appropriate to the age of the child (Thyroid shield, gonad shield, etc.). Fiagbedzi *et al.* reported that not many radiographers used the gonad shield during their examinations, with 56.3% of them using it sometimes (Fiagbedzi *et al.*, 2022). In addition, Directive 2013/59/Euratom states that appropriate medical X-ray equipment, accessories, and practices must be used in every case of medical exposure involving children (ESR, 2015).

Of our radiographers, 92.5% stated that they received basic training in patient radiation protection, whereas only 5% received ongoing training. In fact, radiologists should benefit from intensive training programs in radiation protection, particularly the radiation protection of patients, covering various themes such as knowledge of doses per application, the biological effects of ionizing radiation, and new technologies allowing control of the radiation dose (Paolicchi *et al.*, 2016).

The results showed no association between gender and the practices of the participants. In this context, a study conducted in Saudi Arabia revealed no correlation between participants' knowledge of radiation protection and gender (Omemh, 2022). Furthermore, there is no association between professional experience and the practices of our radiographers. Conversely, a significant relationship ($p = 0.025$) was observed between the number of years of clinical experience and the failure to correctly describe the concept of dose optimisation in a study conducted in Saudi Arabia (Omemh, 2022). However, the current study's population is younger and has less work experience, which may make direct comparisons less relevant. In addition, the uneven distribution of sample sizes could potentially impact the accuracy of the analysis. Specifically, it is important to note that the smaller sample size, in the group with 10-15 years of professional experience may restrict the ability to identify differences, with statistical power.

In the other hand, the results showed an association between the worksite and the question of indicating the number of radiographic examinations repeated ($p = 0.001$), the transcription of dosimetric data necessary for estimating the dose received by the patient in conventional radiology ($p = 0.002$), the availability of protocols for each CT procedure ($p = 0.000$), the adaptation of CT protocols according to the patient's morphological data ($p = 0.001$), And whether or not they have received ongoing training in radiation protection for patients ($p = 0.001$). This result is also confirmed by a study conducted in Cyprus, which showed that the place in which individuals practice makes a difference in their radiation protection knowledge and therefore may serve as a guide for understanding the methods that help ensure consistent radiation training throughout all types of workplaces (Zervides *et al.*, 2020). This results also show that practices relating to the radiation protection of patients differ from one site to another, indicating the lack of a regional strategy aimed at standardizing procedures and radiation protection practices at the level of all radiology departments of the region.

5 Conclusion

One of the shortcomings that health managers in this region must address is the recording of exposure parameters after each imaging procedure and the transcription of these parameters in the reports given to patients for conventional imaging and CT scans. In addition, radiology departments must also be provided with protective equipment and restraints for paediatric imaging. It is also essential to make radiographers aware of the value of using diagnostic reference levels as an important tool for optimising medical imaging doses. Finally, radiographers in this region should be made aware of the consequences of unjustified repetition of radiological examinations.

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Conflicts of Interest

The authors declare no conflict of interest.

Author contribution statement

M. El Fahssi, S. Semghouli, M. Caoui: Conceptualization, Methodology, M. El Fahssi, S. Semghouli, B. Amaoui: Writing original draft. M. El Fahssi, J. Elkhalladi, S. Semghouli, M. Caoui: Visualization, Investigation. S. Semghouli, M. Caoui, L. Jroundi: Supervision. M. El Fahssi, S. Semghouli, M. Caoui, L. Jroundi, B. Amaoui: Reviewing and Editing.

Data availability statement

This article does not contain any studies involving human subjects.

Ethics approval

This study received ethical approval from ethics committee for biomedical research, Mohammed V University of Rabat, under the protocol number 28/22.

Informed consent

This article does not contain any studies involving human subjects.

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