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CODE OF SAFE PRACTICE FOR THE USE OF X-RAYS IN PODIATRY

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1 INTRODUCTION

1.1 The purpose of this Code is to provide criteria for working procedures, x-ray equipment and protective materials necessary for the use of x-rays in podiatric diagnosis according to currently accepted standards of safety. Conformity with this Code may be taken as a primary indication of compliance with radiation protection legislation.

1.2 A copy of this Code is provided to all licensees in podiatric radiography. Licensees shall provide free and convenient access to this Code to all persons using x-ray equipment under their control.

1.3 This Code is compatible with the Recommendations of the International Commission on Radiological Protection (ICRP). Relevant ICRP publications are listed in the bibliography.

1.4 Throughout this Code, measures which are considered necessary for the achievement of satisfactory protection are denoted by the imperative **shall** and those which are desirable protective measures by **should**.

2 PROTECTION OF THE PATIENT

2.1 Clinical and administrative aspects

2.1.1 A basic principle of protection in diagnostic radiology is that an x-ray examination **should not** be performed unless the benefits accruing to the patient outweigh any radiation risks. Judgement of whether benefits outweigh risks may reasonably be possible in cases where the potential radiation injury is the result of acute excessive doses where the effects are observed in the short term. However, the estimates of risks of delayed injury, such as carcinogenesis, resulting from chronic exposure at the low radiation dose levels typical of most diagnostic radiology are derived from epidemiological studies and can be expressed only on a statistical basis. The simpler question of whether the x-ray examination is necessary for adequate diagnosis **should** always be examined. In many cases examinations may routinely be requested to exclude the possibility of unexpected causes or conditions and not be based on clear-cut clinical indications. Implicitly the diagnosis provided by podiatric radiography determines subsequent patient management. If management is expected to be unaffected by the result of an x-ray examination then the need for the examination may be questioned.

2.1.2 Radiological evidence has demonstrated that certain tissues such as the red marrow, gonads, breast (female), lungs, thyroid and bone surfaces may be particularly sensitive to radiation. The total effect of a given dose depends significantly also on the extent of irradiation of other tissues. An expression of the total effect delivered in a diagnostic x-ray examination is the Effective Dose Equivalent, H_E , which is the sum of the doses to the above specified organs and other organs, weighted according to their relative radiosensitivities. For podiatric radiography the effective dose equivalent will be lower than for most diagnostic x-ray procedures because only the bone surfaces amongst the specified organs are included, and no other organs of significant radiosensitivity.

The effective dose equivalent would increase considerably if in any podiatric procedure the x-ray beam were directed towards the lower abdominal region.

The longer life expectancy of children results in a greater potential for the manifestation of possible deleterious effects of radiation. Children may also be more radiosensitive. Therefore particular attention should be given to minimising doses to children and indeed, whether the examination is essential.

2.1.3 The useful x-ray beam **should** be restricted to the area of clinical interest and **shall** be collimated to within the cross section of the x-ray film cassette.

2.1.4 Some methods of dose reduction (such as minimising areas of x-ray fields on the patient) also cause improvement of image quality. However, many dose reduction methods act to the detriment of image quality (eg, use of high-speed rather than par-speed screens decreases doses but increases graininess in the image). A compromise between the opposing objectives to minimise doses and to produce good quality images, must therefore eventually be reached.

2.2 Protection of the gonads

2.2.1 Irradiation of the testes and ovaries **shall** be minimised.

2.2.2 As far as it is possible the useful x-ray beam **shall not** be directed towards the pelvic and lower abdominal regions of patients. Where a special angulation is needed which would not comply with this requirement, a leaded apron or other suitable shield **shall** be draped over the pelvis of the patient or otherwise interposed.

Note: Compared with the amounts of radiation reaching the foetus or ovaries in the case of direct useful beam irradiation of the abdomen, the scattered radiation reaching these organs during irradiation of other parts of the body is small. This is particularly true when only the feet and ankles are irradiated.

3 PROTECTION OF PERSONNEL

3.1 Protection of non-radiation personnel

3.1.1 Persons who are not radiation workers but who work in, or frequent, the podiatric clinic **shall not** be exposed to more than 100 $\mu\text{Gy}/\text{week}$, and **should not** be exposed to more than 20 $\mu\text{Gy}/\text{week}$.

3.1.2 The walls, floors, ceiling and other material constructions of podiatry rooms **shall** have a protective value such that no radiation in excess of the limits stated in 3.1.1 is transmitted through them to occupied positions or areas.

3.1.3 Only those personnel required to assist, or being in the course of training, **should** be present during the performance of x-ray examinations.

3.1.4 If installed, movable or variable protective barriers and leaded doors, etc **shall** be maintained in closed or protective position during x-ray examinations.

3.1.5 The occasional use of non-radiation personnel to give assistance is acceptable but **shall** involve the full use of protective materials and procedures. Care **shall** be taken to ensure that the same non-radiation personnel are not always involved.

3.1.6 There is a multiplicity of factors determining amounts of radiation reaching areas which non-radiation personnel may occupy or traverse. Where the resultant of these factors is uncertain, the use of integrating dosimeters (eg, thermoluminescent dosimeters, radiation monitoring film area monitors) is recommended to estimate the actual amounts of radiation in the occupied areas.

3.1.7 An initial inspection of a new or modified podiatric x-ray room **shall** include tests or measurements for conformity of material protection with that specified in the architectural plans.

3.2 Protection of operator at the x-ray controls

3.2.1 The exposure position at the x-ray controls **shall** be so shielded and located that the exposure rate is as low as is reasonably achievable, social and economic considerations being taken into account, but **shall not** exceed 100 $\mu\text{Gy}/\text{week}$ averaged over a year.

3.2.2 Where the radiation workload is sufficiently low, or where the control position is at a sufficient distance from the x-ray tube and patient that the exposure rate at the operator's position is most likely to exceed 100 $\mu\text{Gy}/\text{week}$, a protective barrier is not required.

Note: Rule of thumb: if the podiatric radiography workload is 10 mA·min/week, the average exposure rate at the x-ray controls 1 m away from the foot or ankle being exposed will be about 20 $\mu\text{Gy}/\text{week}$, averaged over general radiographic techniques. The inverse square law applies roughly for greater distances than 1 m.

3.3 Protection from exposure to the useful x-ray beam while holding patients or image receptors in position during radiography

3.3.1 No person **shall** hold a patient, x-ray film cassette, other imaging equipment or x-ray tube head in position during exposures unless it is otherwise impossible to obtain a diagnostically useful image.

Note: Many cases of delayed radiation injury have been reported in the past resulting from frequent exposure to the useful x-ray beam while holding x-ray films in position. Injury was almost invariably to the hands. Those who suffered these injuries were lulled into a false sense of security by the absence of untoward effects in the early states (ie, a latent period).

3.3.2 Motion-restricting devices **shall** be applied to the patient insofar as it is practicable; and devices for remote holding of the film cassette **shall** be used wherever feasible.

3.3.3 Holding of patients of x-ray film cassettes during exposure **shall** be done by persons accompanying the patient in preference to non-radiation personnel. If it is necessary to use non-radiation personnel it should not always be the same person who does the holding. No pregnant woman or young person should do any holding.

3.3.4 Any persons holding patients or film cassettes in position during exposures **shall** wear a leaded apron and, wherever practicable, leaded gloves. They should ensure as far as is practicable that no part of their body is in the useful beam.

4 X-RAY EQUIPMENT

4.1 Appropriate x-ray equipment

4.1.1 The x-ray machine and ancillary apparatus **shall** be that most appropriate for the x-ray examination.

Note: The central considerations in this requirement are that the x-ray equipment be of maximum effectiveness in image production, and that excessive radiation doses are not delivered to patients during vain attempts to obtain acceptable images with underpowered or otherwise inadequate x-ray machines. In the main these considerations will be related to the ratings of the x-ray machine.

4.1.2 X-ray machines for podiatric radiography **shall** have x-ray tube current (mA) ratings of not less than 15 mA and kilovoltage ratings of not less than 70 kV. Single pulse x-ray generators may be employed.

4.1.3 The x-ray tube **should** have a focal spot of nominal dimensions 1.0 x 1.0 mm or finer to help achieve high resolution images.

4.1.4 A light beam diaphragm **shall** be installed on the x-ray tube head for delineation of the useful x-ray beam on the patient.

4.1.5 The x-ray equipment **should** be a static unit specifically designed for podiatric radiography. Such a static unit **shall** include devices which permit and if possible facilitate radiographic projections uniquely required in podiatric radiography. These **shall** include exposures made while in an erect and weight bearing position. A mobile or portable unit **shall not** be permitted unless there is a specific requirement for such a unit, for example, use in an operating theatre.

4.2 Efficient performance of x-ray machines

4.2.1 To contribute towards an optimal level of efficiency in imaging, the x-ray equipment **should** perform in such a way that a close correspondence exists between actual and nominal technique factors (kVp, mA, mAs, s) and the radiation output is consistently reproducible.

4.2.2 Any assessments of the performance of x-ray machines in respect of efficient performance **should** be made in terms of the parameters in paragraphs 4.2.4 - 4.2.7 inclusive. For these assessments the x-ray machine **should** be connected to an electrical power supply as specified by the manufacturer for that machine. Electrical line volts **shall** be properly adjusted to the indicated value where such adjustment is available to the operator. Measurements **shall** be made with radiation dosimeters and other equipment calibrated and used in a manner acceptable to a qualified expert.

4.2.3 X-ray equipment of any type or model may be submitted to the National Radiation Laboratory for testing for compliance with this Code. The National Radiation Laboratory may in any case require an example of any type or model of x-ray equipment to be so submitted.

4.2.4 The reproducibility of x-ray output **should** be assessed in terms of the coefficient of variation for specified combinations of selected x-ray machine settings. The coefficient of variation of a series of consecutive radiation exposures **should not** exceed 0.10 and **preferably should not** exceed 0.05. (For any sample of observations the coefficient of variation is the ratio of the standard deviation of the sample to the mean value of the sample.)

Note: Experimental evidence suggests that x-ray output variations of $\pm 10\%$ may be readily perceptible on radiographs.

4.2.5 The x-ray output **should be** linearly related to the mA^{*} and mAs^{**} settings within $\pm 10\%$.

* mA: X-ray tube current in milliamperes

** mAs: The product of x-ray tube current in milliamperes and exposure duration in seconds

4.2.6 The deviations of actual peak kilovoltages from indicated or preset peak kilovoltage settings during exposure **should not** exceed $\pm 5\%$ of the indicated or preset value at any x-ray tube current for which the x-ray machine is properly operable.

4.3 Light beam diaphragm

4.3.1 The total misalignment of the edges of the light field with the respective edges of the x-ray field along either the length or the width of the visually defined field **shall not** exceed 2% of the distance from the x-ray tube focus to the centre of the visually defined field when the surface on which it appears is perpendicular to the central axis of the useful x-ray beam.

4.3.2 The centre of the light field **shall** be clearly indicated. The centre of the x-ray beam and the centre of the light field **shall** coincide to an accuracy of within 2% of the distance from the x-ray tube focus to the point on the illuminated surface at which it appears.

4.3.3 The brightness of the light field **should** be sufficiently great that the light field is clearly visible in ambient illumination. The outer edges of the light field **should** be clearly shown with a high edge-field contrast ratio.

4.4 Filtration in the x-ray beam

4.4.1 Filtration **shall** be inserted in the useful x-ray beam to remove the “softer” or lower energy components which otherwise contribute to patient dosage and to scattered radiation levels, without usefully affecting the diagnostic image.

4.4.2 The total filtration in the useful x-ray beam for podiatric x-ray procedures **shall be not less than** 2.0 mm aluminium equivalent.

4.4.3 The total filtration in the useful beam from materials it traverses in the x-ray tube and its housing (ie, the inherent filtration) **should** be permanently marked on the x-ray tube housing as thickness of aluminium equivalent at a nominated kilovoltage.

4.4.4 The filtration in materials in the path traversed by the useful x-ray beam through the light beam diaphragm **should** be permanently marked on the outer cover of the diaphragm as thickness of aluminium equivalent at a nominated kilovoltage.

4.5 Source-skin distance

4.5.1 To minimise the radiation dose to the superficial tissues of the patient and to minimise focal spot penumbra, the x-ray equipment **shall** be so designed and operated as to permit the maximum practicable distance between the source and the patient. Wherever practicable, positive means **shall** be employed to ensure this.

4.5.2 X-ray equipment used for podiatric radiography **shall** permit an FSD* not less than 500 mm. On fixed units the minimum possible FSD **shall** be not less than 500 mm.

Note: X-ray equipment designed for FFDs** of around 700 mm will satisfy this requirement.

4.5.3 On fixed x-ray equipment scales or other indicators **shall** be installed to indicate distances from the x-ray tube focus to the image receptor. The FFD so indicated **shall** be accurate to within ± 10 mm. Where for certain orientations of the x-ray tube assembly such scales or indicators are inoperative other devices **shall** be employed which enable the FFD to be determined with a comparable level of accuracy. Mobile and portable x-ray equipment **shall** employ some method, such as a retractable metallic tape measure, to either indicate or set the FFD to an accuracy of ± 10 mm.

4.6 X-ray exposure device

4.6.1 The onset, duration and termination of x-ray exposures require to be precisely determinable for efficiency of image production and for limiting radiation doses.

4.6.2 A device **shall** be incorporated in the x-ray equipment to terminate radiographic exposures after the elapse of a preset time, or preset mAs. It **should not** be possible to make repeat exposures without release of the exposure-initiating control. It **shall not** be possible to make exposures when the exposure device is set to zero, “0”, or “off”, or equivalent positions. To prevent accidental exposures, the exposure device **shall** require continuous firm pressure on the exposure control for its operation.

* FSD: Distance from x-ray tube focus to incident skin of patient

** FFD: Distance from x-ray tube focus to the x-ray film

4.6.3 The worst fault which may be exhibited by an exposure device is failure to terminate the exposure. It **should** therefore become habitual for the operator to observe the meters at the controls and notice that their readings are consistent with the prior settings and that clear indication of termination independent of the exposure device is given.

4.6.4 The exposure device **shall** determine the exposure accurately and reproducibly.

Notes: (1) In many cases the exposure device interrelates exposure time and x-ray tube current (mAs). Criteria for accuracy and reproducibility of exposures are then expressed in terms of x-ray output.

(2) Where the exposure device determines the exposure time, the actual time **should not** differ from the set time by more than 10% when the set time is 0.2 seconds or greater; and successive exposures should not differ by more than 10%. For individual x-ray machines the linearity of the set/actual exposure time relationship with no zero error may be more important than accuracy.

4.7 Leakage radiation

4.7.1 Leakage radiation emerging from diagnostic x-ray tube housing assemblies **should not** add significantly to scattered radiation already, and unavoidably, present.

4.7.2 Every x-ray tube used for diagnostic purposes **shall** be enclosed in a housing such that the exposure from the leakage radiation at a distance of 1 m from the source **shall not** exceed 1 mGy and **should not** exceed 100 μ Gy in an hour at every rating specified by the manufacturer for that tube in that housing. Diaphragms, cones and other collimating devices **shall** be so constructed that in combination with the x-ray tube housing the whole assembly (ie, the x-ray tube assembly) complies with this requirement.

4.8 X-ray films and intensifying screens

4.8.1 X-ray film and intensifying screen combinations should be the most sensitive to radiation which it is practicable to use consistent with the maintenance of optimum image quality.

4.8.2 Non-screen x-ray film **shall not** be used.

4.8.3 Rare earth intensifying screens **should** be used, contained where possible in cassettes of high radiation transparency.

4.8.4 Intensifying screens and cassettes **shall** be maintained in clean condition, free from blemishes.

4.9 X-ray film processing

4.9.1 X-ray films **shall** be processed properly so that the inherent quality of the latent image is not adversely affected.

4.9.2 Any darkroom **shall** be light-tight, have installed adequate safe-lights, and be protected from ionising radiation. Processing solutions **shall** be correctly prepared, replenished and replaced at intervals necessary to maintain optimum performance.

4.9.3 An automatic x-ray film processor **shall** be used.

5 ORGANISATION AND ADMINISTRATION OF RADIATION PROTECTION

5.1 Personnel monitoring

Where it can be demonstrated that x-ray personnel are unlikely to receive significant doses of radiation in the course of their work, monitoring of occupational exposure is unnecessary, although monitoring may still be performed for the purpose of confirming that occupational exposure is insignificant. The current expectations of podiatric radiography are that it would be described by this situation. The need for, frequency, and personnel to be monitored in podiatric facilities therefore **shall** be determined for each individual facility separately.

Notes: (1) The routine measurement of occupational exposures is presently performed with radiation monitoring film badges (RMF badges). Thermoluminescent dosimeters (TLD) are also available for use in monitoring of x-ray personnel where a light, small dosimeter is needed (eg, on the fingers or near the eyes). The assumption underlying an RMF dose assessment is that the film badge dose is an acceptable approximation of the dose to the part of the body on which it is worn.

(2) For diagnostic x-rays, doses to internal organs will normally be much less than the surface doses. Doses to male gonads may be assumed equivalent to surface doses where, as is usually the case, radiation is anteriorly incident.

(3) Where a leaded apron is worn, the film badge should remain in its normal position on the trunk under the apron; it is then shielded as the trunk is shielded and the dose it receives is the same as that of the trunk.

5.2 Radiation protection surveillance

5.2.1 The safety of a podiatric x-ray installation **shall** be subject to surveillance.

5.2.2 The plans for new podiatric x-ray installations or for extensive modifications of existing installations **shall** be submitted to a qualified expert for advice on the necessity, and specification, of x-ray room shieldings.

5.2.3 The licensee is legally obliged to ensure that safe working procedures, as laid down in the licence, or in the Regulations, are being adhered to. This includes amongst other things the regular and correct use of radiation monitoring film badges or other personnel monitoring procedures if these have been required.

5.3 Dose limits for occupational exposure

5.3.1 Dose equivalent limits for occupational exposure to radiation are prescribed in the Radiation Protection Regulations 1982.

Calculations of the dose equivalent in any particular case require dose estimates for specified organs and the complexity of this procedure may not be justified on a routine basis. For all practical purposes in podiatric radiography, it will suffice that the working dose limit for occupational exposure be 1 mGy/week measured as absorbed dose to air in occupational areas and allowing for occupancy factors. Since doses to internal organs are always less than the absorbed dose in air at the same position, compliance with the working limit of 1 mGy/week will automatically ensure compliance with the limits specified in the regulations.

5.3.2 The dose equivalent limit is used only as a guide in dose limitation. Doses “should be as low as reasonably achievable, social and economic considerations being taken into account” (ALARA). This means that a dose level already below the limit, **should** be reduced to the minimum practicable.

6 RADIATION PROTECTION LEGISLATION AND RESPONSIBILITIES OF LICENSEES

6.1 Radiation Protection Act 1965

The Radiation Protection Act 1965 and amendments, and its Regulations, 1982, govern the safe use of irradiating apparatus (in the main, x-ray machines) and radioactive materials in New Zealand. The Act is administered in the Ministry of Health by the National Radiation Laboratory (NRL). The legislation is compatible with international recommendations such as those of the International Commission on Radiological Protection (ICRP). Radiation protection inspection visits may be made periodically by officers from the National Radiation Laboratory to assess compliance with the legislation and this Code. The following points arising from the Act and Regulations are noted, but the reading of these is neither intended as a substitute for reading of the Act and Regulations themselves, nor is it claimed to be an exhaustive coverage of points of interest for users of diagnostic x-ray machines. Copies of the Act and relevant Regulations together with any codes of safe practice (such as this one) are required to be made readily available to x-ray personnel by the licensee in any establishment.

6.1.1 No person may use a diagnostic x-ray machine unless that person is the holder of a licence issued under the Act, or is acting under the supervision or instruction of a licensee (Clause 15 of the Act). Persons normally eligible for licences for podiatric radiography are those who have successfully completed approved courses in podiatric radiography techniques and interpretation, and radiation protection.

6.1.2 Licences are issued subject to conditions prescribed in the Act and Regulations. Individual licences may additionally be subject to conditions such as restriction to a specified machine or to machines of a specified kind, or to a specified range of x-ray examinations (Clause 17 in the Act). In the case of podiatric radiography the conditions on the licence will be the same as, or similar to, the following:

(i) Fluoroscopy is excluded.

(ii) Radiography shall be confined to the feet and ankles only.

(iii) The x-ray machine together with its ancillary equipment **shall** be purpose designed for podiatric radiography and **shall** comply with the requirements of *NRL C10 Code of safe practice for the use of x-rays in podiatry*.

6.1.3 Licensees may not perform or instruct performance of x-ray examinations not included specifically or implicitly in the purposes of their licences. For example, podiatrists **shall not** perform medical radiography.

6.1.4 The licence issued is personal to the holder and is not transferable. This is because a licence is granted to a person only when NRL is satisfied that person is able, with a knowledge of safe working and with the equipment to be used, to carry out the proposed use safely.

6.1.5 All licensees are responsible for the safe care and use of x-ray machines which come under their control, and they retain this responsibility until it has been properly transferred to another person or terminated in accordance with the Regulations.

6.1.6 If the owner of any irradiating apparatus sells or transfers it in any manner to another person, the owner is required to ensure that the purchaser is the holder of an appropriate licence or employs a person appropriately licensed. The owner is required to notify NRL of the sale or transfer.

6.1.7 A licensee is required to notify the Director-General of Health (which can be done by notice to NRL) of any case of overexposure or suspected overexposure to radiation, as soon as possible after becoming aware of it.

7 SERVICES FROM NATIONAL RADIATION LABORATORY

Licensees may consult NRL for advice and for provision of personnel monitoring and other services such as protection surveys, measurements of patient dosage or x-ray machine radiation output, and advice on the need for, and specification of shieldings for x-ray rooms. Charges may be made for some of these services.

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