REVIEW ARTICLE

Radiation Cataractogenesis: The Progression of Our Understanding and Its Clinical Consequences

Danyal Zaman Khan, Marie Constance Lacasse, MD, FRCPC, Rizwana Khan, MD, and Kieran J. Murphy, MD, FRCPC

ABSTRACT

In the high-volume and increasingly complex world of image-guided therapy and medical imaging, awareness of the potential risks secondary to occupational radiation exposure in medical professionals needs greater focus. One of these risks is radiation-induced cataracts, a recently recognized entity, which may impact the physician's professional proficiency, quality of life, and career span. This review article aims to explain the pathogenesis of radiation-induced cataracts, exploring emerging evidence regarding their development. It also explores the existing monitoring and protection measures available to protect against such radiation-induced pathologic conditions.

ABBREVIATIONS

ICRP = International Commission on Radiological Protection, O'CLOC = occupational cataracts and lens opacities in interventional cardiology, OR = odds ratio, PSCC = posterior subcapsular cataract

Radiation-induced cataracts secondary to occupational exposure represent a recently recognized entity. In the rapidly expanding world of medical imaging and image-guided therapy, awareness about the potential radiation risks to medical professionals has to be emphasized. Knowledge and constant reinforcement of the basic radiation protection principles are required to decrease unnecessary radiation exposure. Therefore, the present article explores our development of understanding of the pathogenesis of radiation-induced cataracts and its close link with radiation-induced oncogenesis. This is followed by discussion of existing monitoring and protection measures available to protect against such radiation-induced pathologic conditions.

From the Royal College of Surgeons (D.Z.K., R.K.), Dublin, Ireland; and Department of Radiology (M.C.L., K.J.M.), Toronto Western Hospital, University Health Network, University of Toronto, 3MC 424, 399 Bathurst St., Toronto, Ontario, Canada M5S 3E2. Received January 8, 2016; final revision received November 2, 2016; accepted November 19, 2016. **Address correspondence to** K.J.M.; E-mail: kieran.murphy@uhn.ca

None of the authors have identified a conflict of interest.

J Vasc Interv Radiol 2017; XX:▮▮▮–▮▮▮

http://dx.doi.org/10.1016/j.jvir.2016.11.043

MATERIALS AND METHODS

We obtained anatomic pathology specimens of human lens with posterior chamber cataracts (**Figs 1–4**). A systematic literature search was performed by the authors using the PubMed database (US National Library of Medicine, National Institutes of Health) and the initial terms "radiation-induced cataracts" and "lens occupational radiation monitoring and protection." Any further searches were more specific to source information regarding radiation-induced oncologic pathologic conditions of relevance to the scope of this document. Inclusion criteria for initial literature searches were broad and as follows: full-text articles published in English between the years 1950 and 2016 with the subject matter of radiation-induced cataract pathogenesis, lens dose monitoring, or radiation protection strategies. The exclusion criteria were formed from the converse of the inclusion criteria. By reading the titles or abstracts, the same authors excluded studies not fulfilling the parameters set by the inclusion and exclusion criteria. Each remaining article was reviewed, and relevant information was extracted if in congruence with the scope of the paper. This information is presented as part of the paper's Results and Discussion. This search strategy is presented in **Figure 5**.

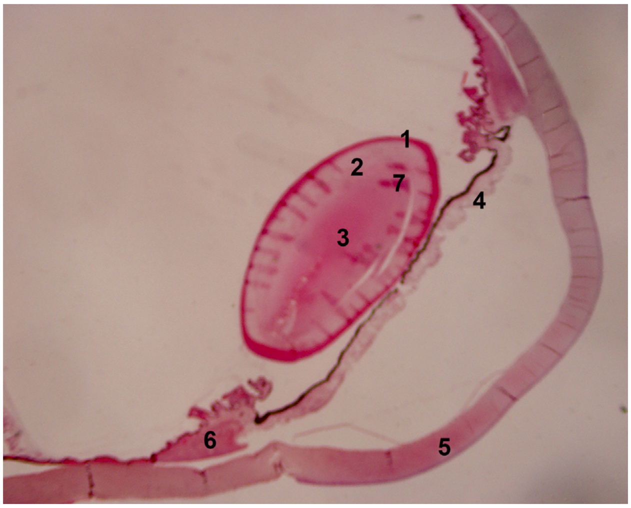

Figure 1. Normal lens showing (*1*) lens capsule, (*2*) peripheral lens fiber, (*3*) nucleus with higher concentration of lens fibers, (*4*) iris, (*5*) cornea, (*6*) ciliary body, and (*7*) artifact.

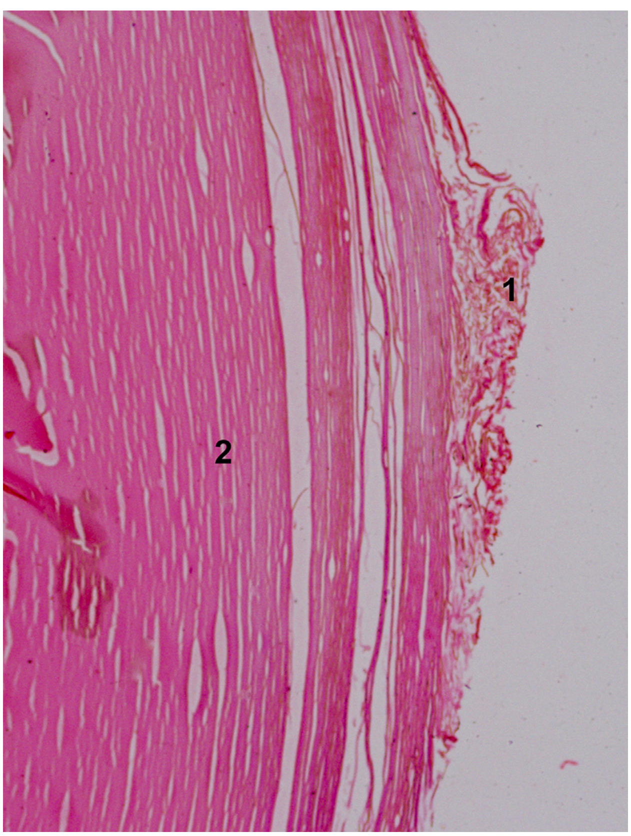

Figure 2. PSCC shows (*1*) the presence of a layer of epithelial cells under the posterior capsule, which have migrated from the equatorial cells. (*2*) The lens fibers still maintain some normal appearance.

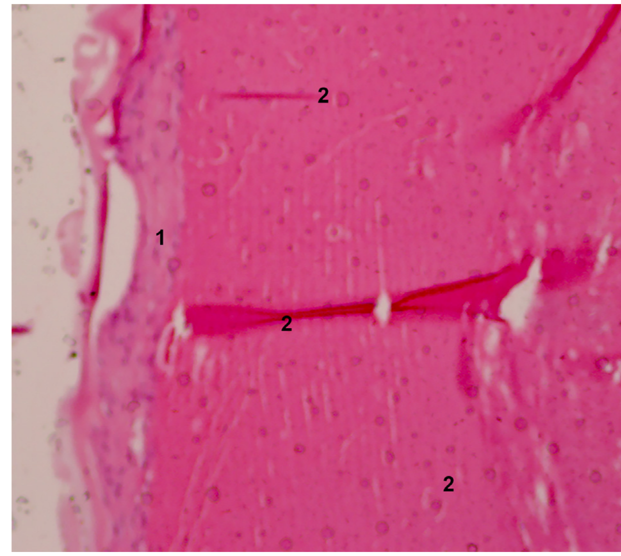

Figure 3. PSCC with (*1*) epithelial cells under the posterior lens capsule that have migrated from the equator or lens bow cells and (*2*) artifacts.

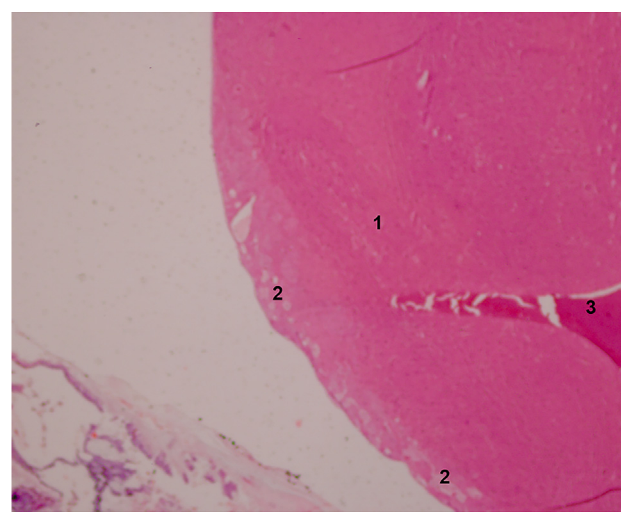

Figure 4. Nuclear cataract showing (*1*) lens fibers that have lost their concentric lamination, giving rise to homogenous eosinophilic appearance; (*2*) separation of lens fibers during slide processing; and (*3*) artifact.

RESULTS AND DISCUSSION

Pathogenesis of Radiation-Induced Cataracts

Modern cataract surgery uses an emulsification process to minimize incision size, so no anatomic specimens are obtained. After extensive searching, we found anatomic pathologic specimens of the human lens in a pathology museum. The unique structure of the lens is fundamental to its refraction capabilities, and is the basis for its high radiation sensitivity and the unique pathology of cataracts (1) (**Fig 1**). The development of cataracts results from the opacification of the lens (1). It is the main cause of blindness worldwide, and the second most common reason for visual impairment after uncorrected refractive errors (2). Age-related "senile" cataracts are the most common type of cataracts (3).

Cataracts are the classified anatomically into nuclear, cortical, and posterior subcapsular subtypes (1). Nuclear and cortical cataracts develop from pathologic changes