Title

Electronic Integrated Diagnostic Report for Presenting Results of Breast Imaging and Breast Biopsy

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Electronic Integrated Diagnostic Report for Presenting Results of Breast Imaging and Breast Biopsy

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Abstract: Most breast imaging practices have an organized system for reviewing the results of breast biopsies, assessing radiologic-histologic concordance, and making follow-up management recommendations. Yet, historically, the breast pathology report and radiologic addendum have been separated within the electronic medical record. Having the two entities fused into one integrated diagnostic report (IDR) has provided both a concise summary of the pertinent findings of imaging and histologic examinations related to the patient's care and clear guidance for treatment and follow-up. Direct correlation between imaging and histologic findings has been shown to decrease discordance between these findings and increase diagnostic accuracy. The IDR is also a useful summary for conferences of tumor boards and multidisciplinary clinics. In addition, the software that is used for generating the IDR is capable of identifying patients who may benefit from clinical trials.

Keywords: *integrated diagnostic report, radiologic-histologic correlation, concordance*

Discussion

The development of the integrated diagnostic report (IDR) involved a coordinated effort of the department of radiology (including both radiologists and software designers) and the department of pathology. Given that the development of the IDR promised to reduce radiologic-histologic discordance or potential misdiagnoses, it was thought that this development would be a worthwhile endeavor.[1,2,3] The Breast-IDR is built on the integrated diagnostic (IDx) platform that uses the Java-based Grails web application framework to identify and integrate clinical data and to structure the report. As in the IDRs developed for integrating radiologic and histologic clinical data with reports for diagnosis of lung cancer and targeted prostate biopsy,[4,5] the data feed in the Breast-IDR comes from three sources: the laboratory information system, the picture archiving and communication system (PACS), and the active directory with a single sign-on server. In addition, the Breast-IDR incorporates mammography reporting and tracking software (MagView; Applied Software Inc) and breast imaging viewing system (SecurView; Hologic Inc) synchronized with PACS and the sign-on server.

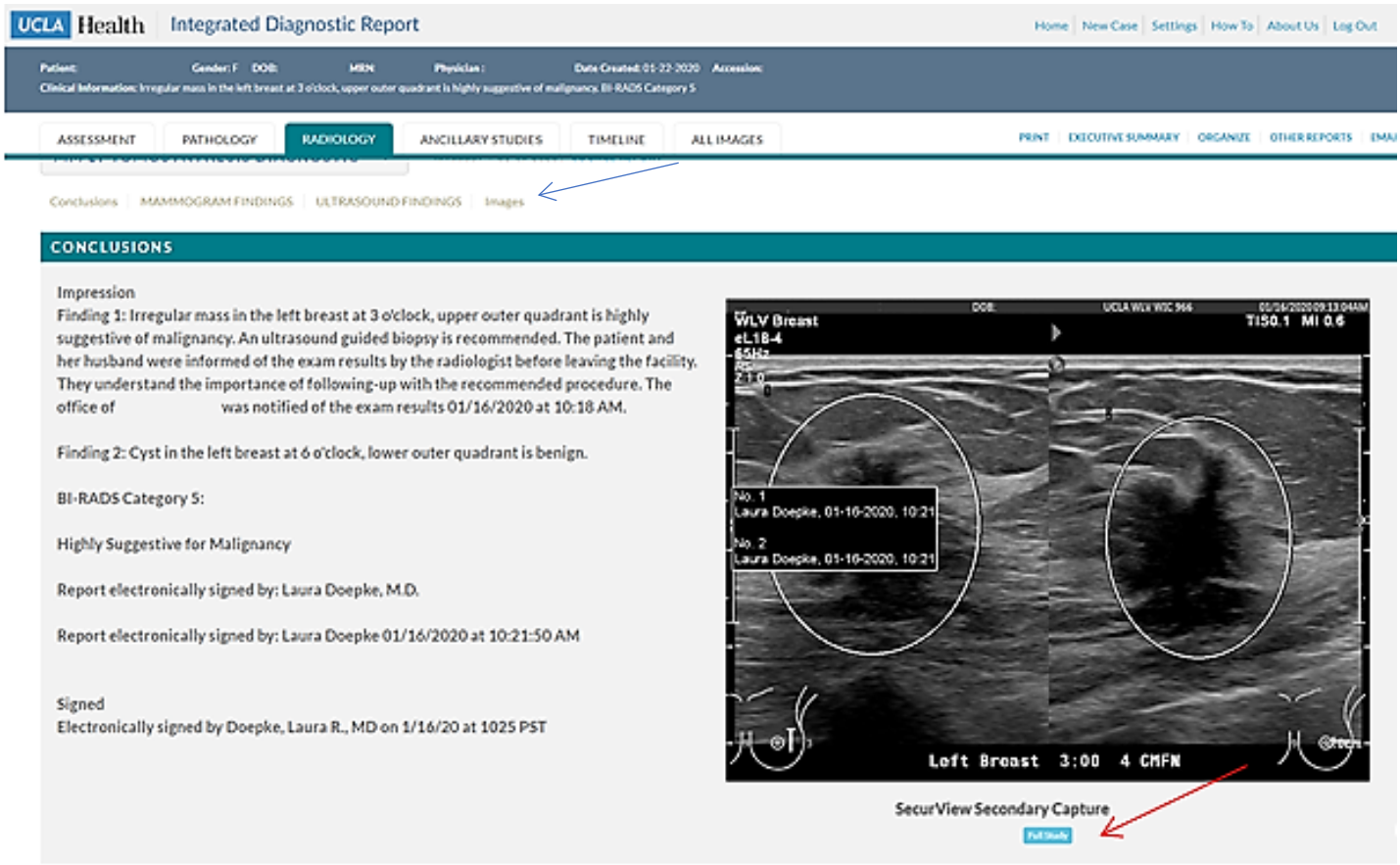
The generation of a specific report on Breast-IDR begins at the time of a medical work-up. When a patient is seen for a diagnostic mammogram and/or ultrasound, the pertinent finding (eg, mass, calcifications, architectural distortion) that is recommended for biopsy is circled on diagnostic images within SecurView. Once the study is marked as read, the annotated images are sent to

PACS and saved as significant images. These images will then be identified and integrated into a final report on the Breast-IDR (Figure 1).

The completion of a biopsy and reviews of the results of imaging and histologic examinations triggers the generation of the Breast-IDR. At this time, all relevant images and examination reports are integrated into the IDR (Figures 1, 2, 3). In some instances, a finding on a screening examination is indeterminate and can lead to additional work-up. However, given that most "callback findings" prove to be benign and are not biopsied, screening findings are omitted from the IDR.

Once the results of histologic examination become available, a standardized addendum to the biopsy report is issued in Magview according to the options available in the pull-down menus. In the addendum, the radiologist not only enters the histologic diagnosis from the options available in the digital library, but also, and more importantly, addresses whether the results are concordant with the imaging findings and makes a clear recommendation for follow-up. Once the standardized addendum is issued within MagView, the integrated radiology-pathology report is finalized automatically with creation of hyperlinks from the source reports to the Breast-IDR case. For patients with a diagnosis of breast cancer based on the results of a core needle biopsy, the specific biomarkers are also added. Because the report is generated prior to the completion of fluorescence in situ hybridization (FISH) testing, the preliminary ERBB2 (formerly HER2/*neu*) gene status is entered as follows: Positive 3+, Equivocal 2+, Negative 1+ or 0. After the FISH report is

Figure 1. Breast-IDR Radiology Page Showing Significant Images

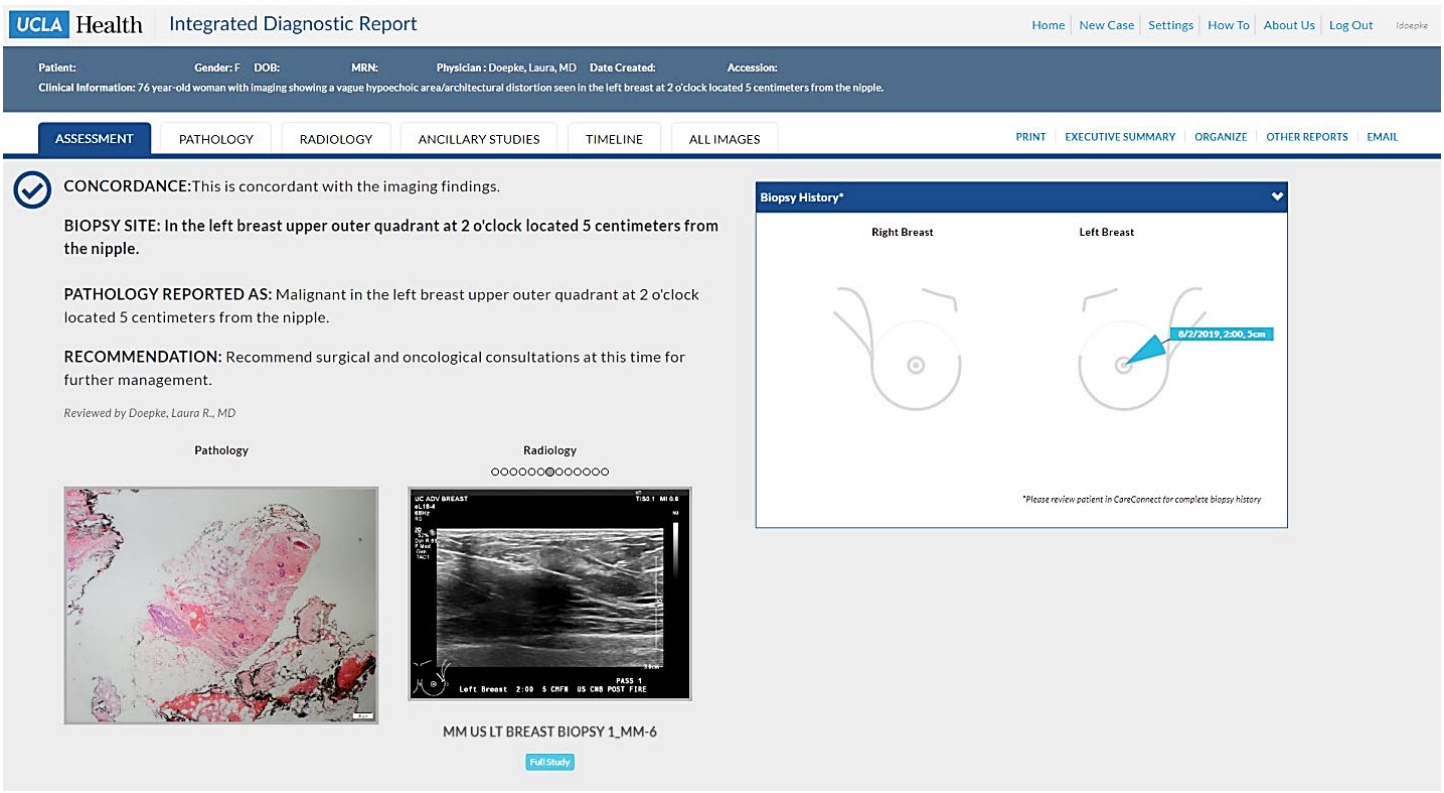


The blue "Full Study" button (red arrow) provides access to all images of the biopsy. The "Images" button (blue arrow) provides access to all radiologic studies performed on the patient.

issued and the final ERBB2 gene status is complete, the data are automatically uploaded into the Breast-IDR (Figure 4).

The Assessment page of the Breast-IDR displays a "Biopsy History" diagram of the breasts with hyperlink labels indicating the sites of the breasts that have been biopsied (Figure 5). The "Additional Findings" section (Figure 6) on the Assessment page of the Breast-IDR provides recommendations for patients who may need follow-up (the source report BI-RADS Category 3 recommendations for management of other findings that were not biopsied). Furthermore, the section hyperlink provides access to the diagnostic report with additional findings that require follow-up (Figure 7). Finally, a "Timeline" tab on the Breast-IDR user interface provides access to the summary of all imaging (including cross-sectional

Figure 2. Breast-IDR Assessment Page Showing Images of an Ultrasound-guided Breast Biopsy.



Note the prominent concordance assessment.

imaging) and pathology examinations that a patient underwent in David Geffen School of Medicine at UCLA. The blue "View Imaging" button (Figure 8) on the "Timeline" page provides direct access to any prior imaging examination of a particular patient. This function is useful in clinical settings where maintaining patient privacy is important while showing patients their imaging studies; it allows opening the images without accessing PACS and exposing other patients' information on the screen. In addition, the "view imaging" button is exceptionally useful for conferences of tumor boards and specialty clinics[6,7] when quick access to imaging is highly desirable.

The Breast-IDR has shown to be a useful tool in research and data mining.[7] Subsequent to its creation, in a recent clinical trial that evaluated response to neoadjuvant chemotherapy in patients with triple negative breast cancer, the Breast-IDR has been tested for its capacity to identify patients with newly diagnosed breast cancer and specific tumor subtypes. The Breast-IDR completed this test quickly and accurately. This is of great value to patients who may benefit from new therapies. In addition to research and

therapeutic applications, the Breast-IDR can be helpful for improving practice patterns of physicians. The development of a dashboard that will catalog all biopsy recommendations made by each radiologist is underway. This will provide a concise summary of both the imaging that led to a biopsy and the biopsy results. The purpose of this dashboard is to educate radiologists on the positive predictive value of their biopsy recommendations with the goal to improve practice patterns and reduce unnecessary biopsies.

Conclusion

In summary, the Breast-IDR is useful to referring doctors, radiologists, and pathologists in accessing diverse information with sufficient granularity for better decision-making. It is a valuable medium for communicating with patients. It can also be utilized for research and therapeutic purposes by identifying patients who may benefit from life-saving clinical trials. This novel integrated diagnostic report will continue to show its value as medical science progresses.

Figure 3. Breast-IDR Pathology Page with Photomicrograph of a Biopsy Sample Showing Invasive Ductal Carcinoma.

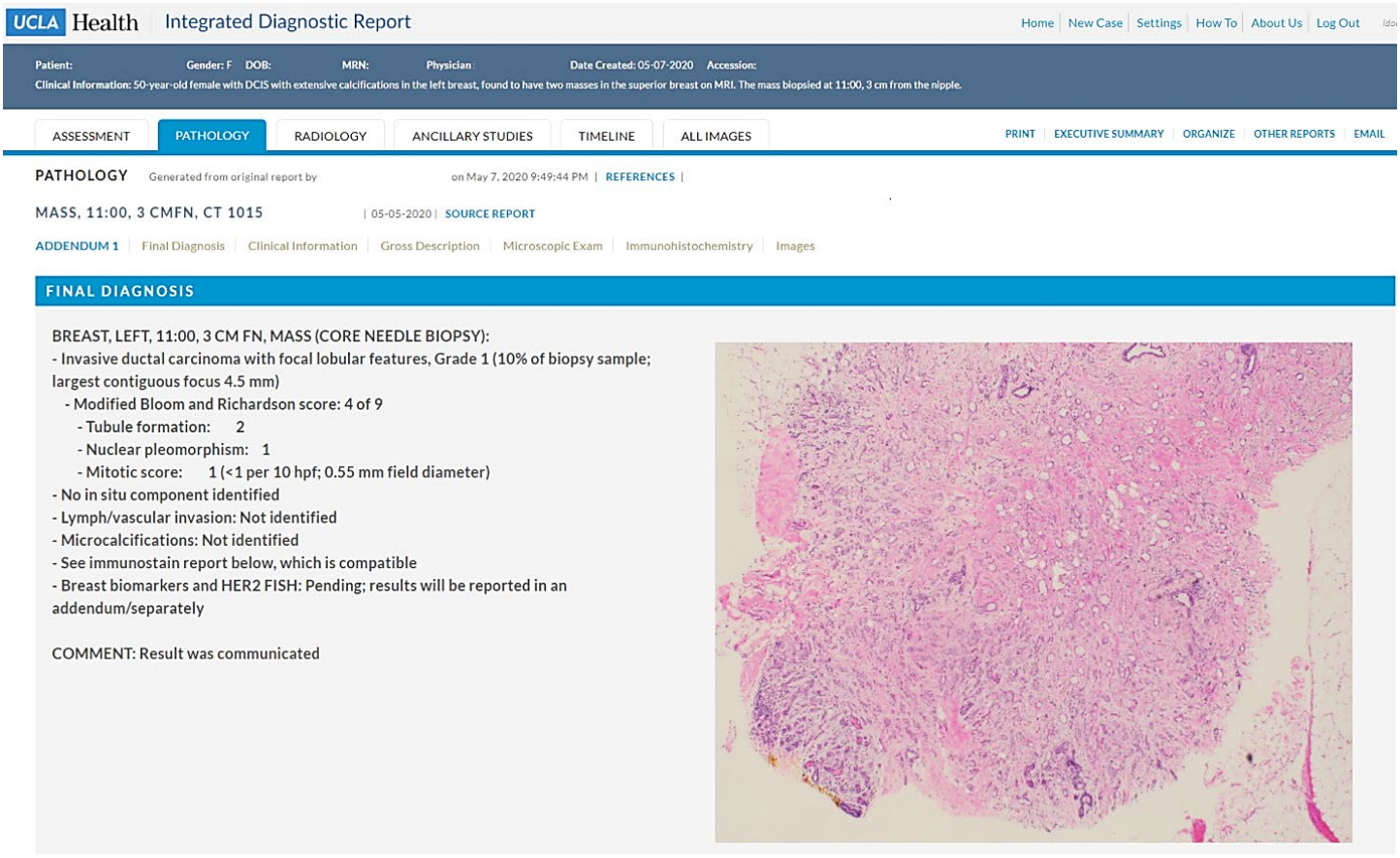


Figure 4. Breast-IDR Ancillary Studies Page Showing the Results of FISH Testing

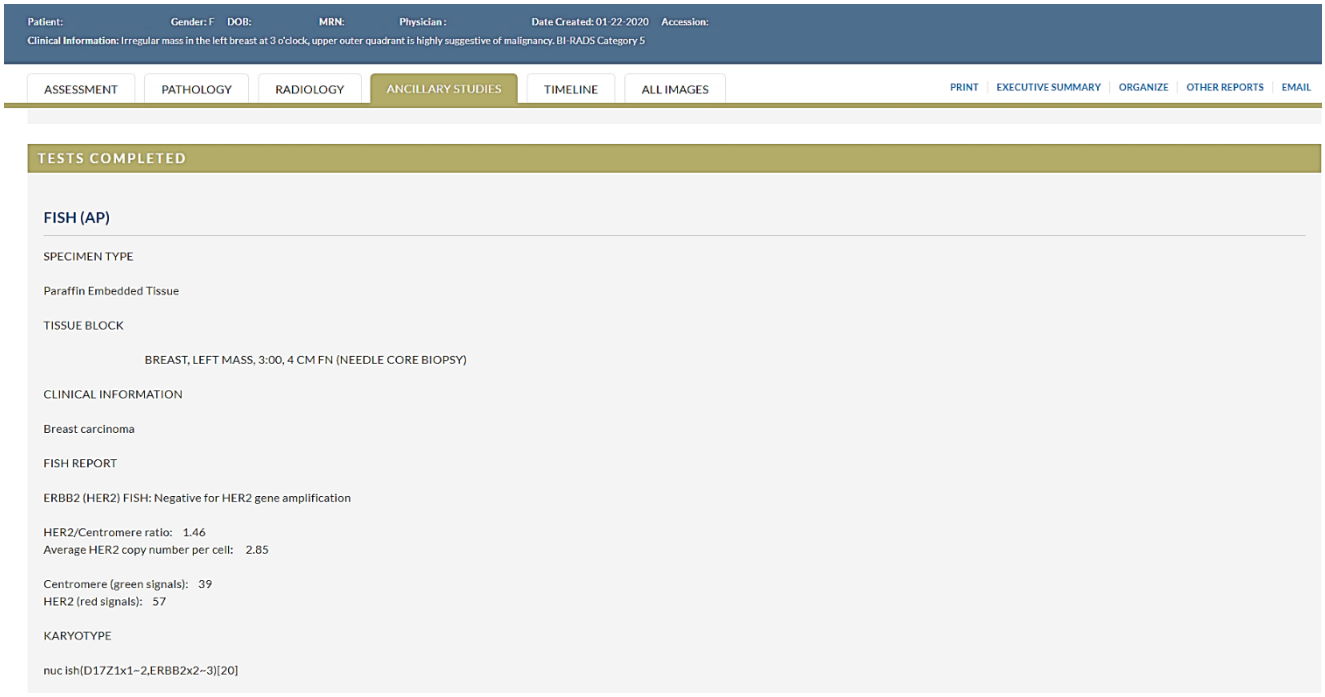
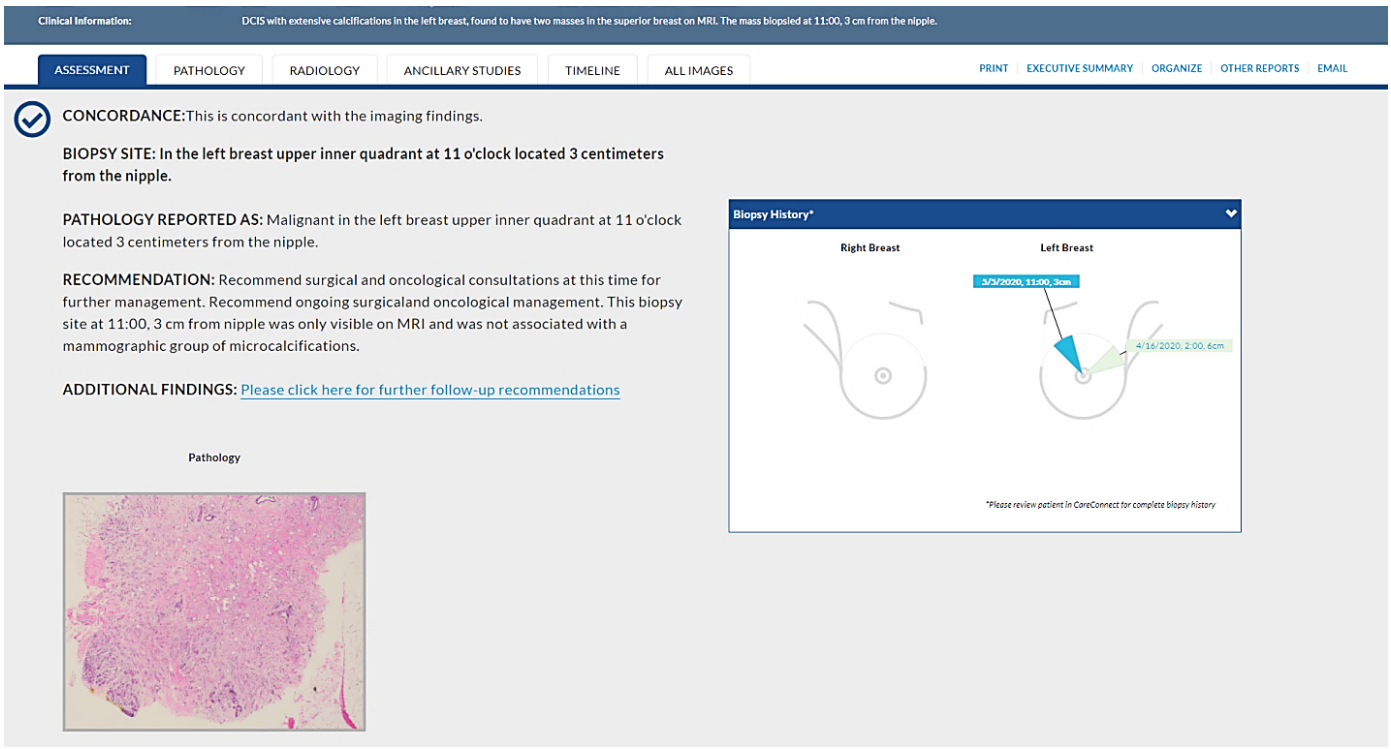
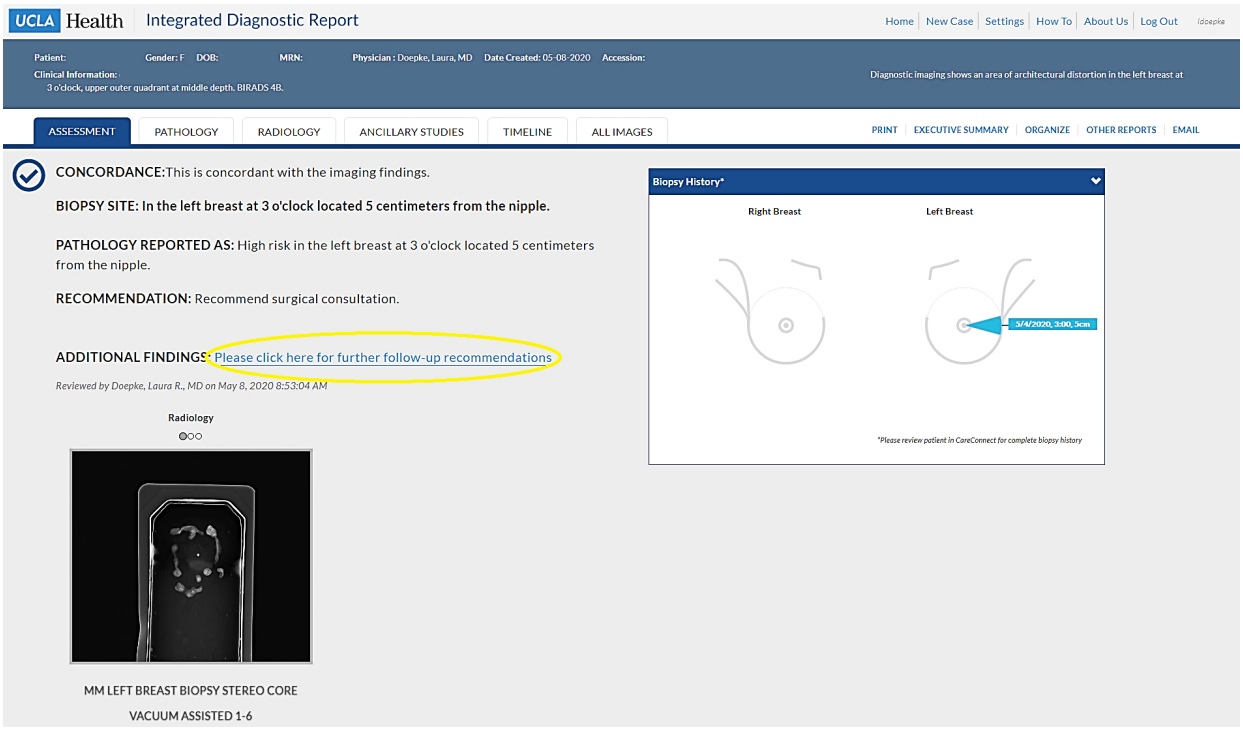


Figure 5. Breast-IDR Assessment Page with Links to Results of Biopsies of Several Sites.



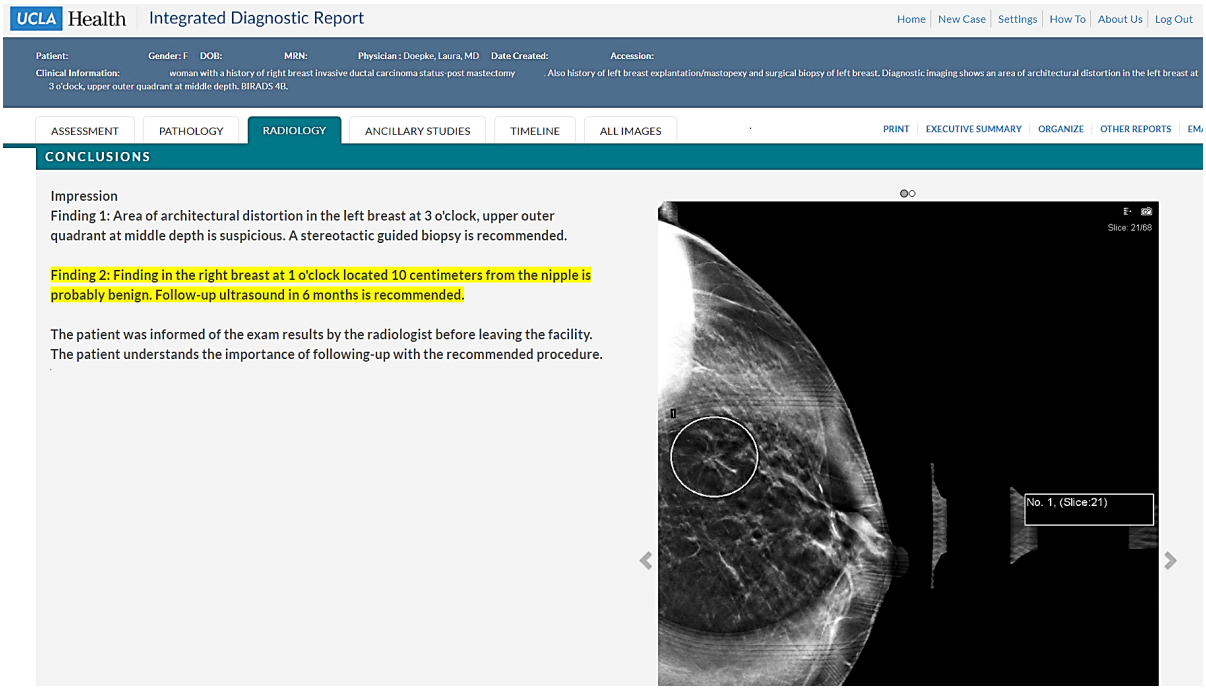
The biopsy sites specified by the blue (Left Breast 11:00, 3 cm FN) and the green (Left Breast 2:00, 6 cm FN) hyperlink labels with color-coordinated arrows. The photomicrograph of lesional biopsy specimen corresponds with the highlighted blue label and arrow. The green (dimmed) label and arrow provide access to the results of biopsy from the second site. Note the prominent concordance assessment statement on the first line of the report. Presented in every case of the Breast-IDR, this statement provides a clinician with clarity regarding adequacy of sampling and consistency of histologic and radiologic findings.

Figure 6. Breast-IDR Assessment Page with the Stereotactic Biopsy Image Showing Radial Scar.



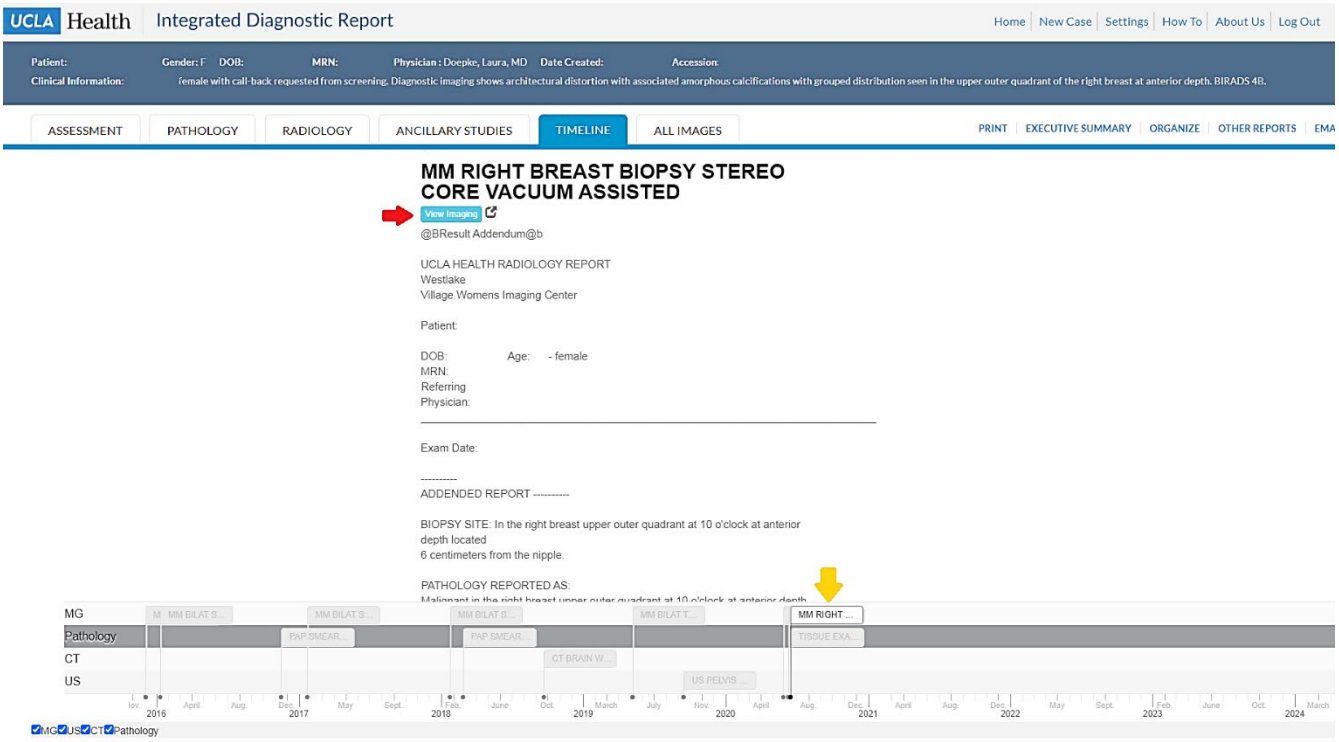
The patient had additional findings that require follow-up. The "Additional Findings" section has a hyperlink (yellow ellipse) pointed to follow-up recommendations.

Figure 7. Breast-IDR Radiology Page Showing Follow-up Recommendations.



This page can be opened through a hyperlink in the "Additional Findings" section on the Assessment page of the Breast-IDR. Any finding that requires follow-up is highlighted (yellow highlight) and provided with the recommended imaging modality and follow-up time interval.

Figure 8. Breast-IDR Timeline Page.



The highlighted report (gray bar) of the shown study is mapped onto the timeline of the patient's clinical and diagnostic history (yellow arrow). The blue "View Imaging" button (red arrow) provides access to the case-relevant images.

Author Contributions

Conceptualization, D.E. and L.D.; Acquisition, analysis, interpretation of data, and writing – original draft preparation, L.D.; Review and editing, C.A., A.H., and D.E.; Supervision, D.E. All authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All authors had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Disclosures

None to report.

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