Retrospective Research in Radiology From Concept to Publication: A Stepwise Guide for Trainees and Mentors

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OBJECTIVE. The purpose of this article is to describe a step-by-step approach to the successful mentorship of trainees completing retrospective radiology research projects. The topics addressed include selection of a mentor and mentee and the selection, planning, initiation, and completion of a retrospective research project.

CONCLUSION. Mentoring a trainee in the completion of a retrospective research project is an ideal way to introduce a trainee to academics. The goals of such a project given the time constraints of radiology residents include completion of an educational exhibit, an oral scientific presentation, and a published manuscript.

It is important for a radiology trainee to be exposed to research, because the experience provides insight into academics, enhances a trainee's appraisal of the literature, and may help the trainee decide on a career path that entails academics. The key to success is effective mentoring, from initiation of the research project to completion of the manuscript. Although the completion of a research project can be gratifying to a trainee, the positive influence of mentoring cannot be underestimated and can be rewarding to all [1–9].

We describe a step-by-step approach to the successful mentorship of trainees initiating a typical retrospective radiology research project. The focus is a retrospective project given the time limitations of many trainees. We aim to show that when the process is broken into discrete steps, the completion of a research project from initial idea to manuscript is not as difficult as it may seem otherwise.

Selection of a Mentor and Mentee

When a faculty member has a research idea, it may be tempting to directly ask a trainee to collaborate on a project during an image interpretation session. This approach is not ideal, because the trainee may feel pressured to agree to the project but may not be truly interested. Alternatively, the mentor can solicit a volunteer by sending an e-mail to the trainee group with several research ideas, clearly delineating the type of work and time commitment expected from the trainee. Trainees may also be encouraged to directly approach a faculty member to inquire about a possible research project.

Selecting a Research Project

It is common for trainees to be apprehensive about pursuing an academic career because they lack research ideas. Reassurance should be provided because many research hypotheses originate from a clinical observation, a particular imaging finding, a pathologic process, or a specific teaching point, which becomes more evident with clinical experience. Research concepts that have relevant, practical teaching points have a higher likelihood of publication. A successful research concept usually originates from faculty mentors because of their years of experience and familiarity with the current literature and timely topics. A mutually agreed-on research project is then selected, and a preliminary hypothesis is constructed.

Expectations, Deadlines, and Authorship

At the first meeting between mentor and mentee, it is essential to discuss the details and expectations of the research project. A usual mutually agreed-on timeline would include completion of an educational exhibit, a paper presentation, and a manuscript with deadlines for every step (Appendix 1). The educational exhibit reviews a broad educational perspective around the research topic,

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whereas the paper presentation stems from the hypothesis-driven manuscript.

The project timeline is created around conference deadlines. A typical scenario would consist of submitting an educational exhibit abstract in the spring for a fall meeting and submitting the abstract of the oral paper presentation in the fall for a subsequent spring meeting. Construction of a manuscript should occur before an oral presentation to avoid being "scooped" if another author publishes on the topic before the paper submission. Writing the manuscript affords excellent preparation for an oral presentation. The manuscript is submitted immediately after the oral presentation, when audience comments and feedback can be incorporated into the manuscript (Appendix 2).

Authorship order, roles, and degree of involvement of other authors must be determined explicitly at the beginning of the project. All authors must make a substantive intellectual contribution as described by International Committee of Medical Journal Editors guidelines to ensure proper authorship ethics [10]. The trainee should be the first author of the educational exhibit if he or she constructs the exhibit. If the trainee gives the oral presentation, he or she should be first author on the abstract. The trainee should be the first author on the manuscript if he or she constructs the first draft and sees the project to completion. The mentor may be the second author as primary author or the last author as senior author. It is important to indicate this arrangement in one's curriculum vitae to receive credit for primary authorship on such projects when a trainee is the first author.

Literature Search

The trainee should be given 1–2 weeks to complete a literature search, during which the mentor simultaneously performs the same search. Internal institutional support, such as the medical librarian, is often available for assistance. The two sets of results should be compared and important articles reviewed to obtain an overview of the subject and current literature.

Project Design and Institutional Review Board Submission

Several types of retrospective research studies can be considered, including case series (study of a group of patients with a specific disease, ideally compared with a control group without the disease, i.e., a case-control study), cohort (investigation of a specific group of patients for disease occurrence), and cross-sectional (assessment for the presence of a disease in a broad cross-section population sampling). After selection of the type of retrospective study, attention should be shifted to constructing an abstract and the study design. This step usually involves consultation with a statistician to assess the methods of data collection and analysis and a power calculation to ensure inclusion of the appropriate number of subjects. At this point, it may be helpful to perform a limited feasibility search of radiology reports or records to determine whether there are adequate cases, although the results should be deidentified and not evaluated without institutional review board (IRB) approval.

Once the project has been well designed, the IRB application can be written and submitted. The mentor should provide assistance with the IRB application because many trainees may be unfamiliar with the process. Often there are individuals at one's institution who can be used as an important resource in this process. The trainee should use the time waiting for IRB approval to become familiar with the topic through reading of related papers.

Educational Exhibit

The theme for the educational exhibit should be derived from the research question submitted to the IRB but should have a broad educational focus. By working on the educational exhibit, the trainee will become well acquainted with the subject from a broad perspective before focusing directly on the research project hypothesis. Including in the educational exhibit abstract the types and numbers of cases identified in the scientific project increases the chance of acceptance.

Scientific Project

After IRB approval, cases are identified for the retrospective study. It is vital to design a comprehensive, definitive search that will result in a large initial number of subjects, minimize selection bias, and avoid the need for repeated searches. Many flawed projects stem from a problem in the initial step of case selection. Database searches may be completed via keyword search of the radiology information system or other hospital databases. It is important to include variations in keywords and their spelling to capture all studies. Internal institutional support may exist for this process.

The next step is for the trainee to populate a spreadsheet with the patient background data. This is another key stage at which an error can create serious flaws in methods and possibly extra work. Examples of the data included in the spreadsheet are patient research number, age, sex, image side (right or left), date of a specific imaging study, imaging findings (by report), and clinical, medical, surgical, and pathologic data.

Every attempt should be made to put data into specific categories and to use numeric data. For example, the status of a ligament from a radiology report can be coded (e.g., 0, normal; 1, partial tear; 2, complete tear). The categories should be similar among all imaging methods and based on the accepted standard of reference, such as surgery. Even patient sex should be categorized as a number (e.g., 0, female; 1, male). This assists the statistician in analyzing the data.

To identify errors early in the process, the mentor should review the design of the spreadsheet before data entry and after data on the first six to eight subjects have been recorded. These preliminary steps are crucial to the accuracy of data collection. The goal is to have the trainee review the clinical chart data only once when completing the spreadsheet. The trainee should also be instructed not to delete any subjects because of exclusion criteria at this early step but rather to move the data to another spreadsheet. This way the data are still available if needed at a later date. This and related digital files should be stored in more than one secure, password-protected location and be named appropriately to include the date of file revision.

Once cases are identified after application of inclusion and exclusion criteria, a retrospective review of images is completed with the coauthors who will act as coreaders. Independent review is preferred over consensus reading. Calculation of interobserver and intraobserver variability strengthens a study. The readers may undergo a training session to acquaint them with important imaging findings, the predetermined grading scale, and the topic at hand. It is recommended that one hard-copy data sheet be used for each patient and that the options on the data sheet be discrete categories so that the reviewers will commit to a specific finding. Writing free text or descriptions creates ambiguous data.

The readers should be blinded as directed by the study design. Information from each subject's data sheet can then be entered into the initial spreadsheet. The statistician can then analyze the spreadsheet to provide significance to specific observations, sup-

porting or disproving a specific hypothesis. During this time, the trainee can begin construction of the manuscript.

Manuscript Composition

It is unrealistic to expect a trainee with little research experience to produce a finished manuscript in a single draft. A stepwise approach is much easier, allowing continuous interaction and feedback and ensuring that the direction of the paper and writing style are consistent between mentor and trainee. The trainee should be familiar with the checklist from the Standards for Reporting of Diagnostic Accuracy [11]. Construction and formatting of the manuscript should follow the guidelines of the specific journal. Carelessness and poor attention to detail give peer reviewers a negative impression and make their job more difficult. Like the data files, the manuscript documents should be stored in several password-protected locations with an appropriate file name that includes the date of file revision.

Introduction

The first step in the manuscript process is writing the introduction. A typical template for the introduction is three paragraphs. The first paragraph (approximately three sentences) should explain why the topic is relevant, provide a brief background, and focus the reader on the hypothesis. The second paragraph provides a brief review of other research on the subject. The final paragraph explains why the project was completed and presents the hypothesis, addressing the "so what?" factor. In writing the introduction, the trainee and mentor first review the outline and then review the first draft of this section. Edits are made with the track changes feature of the word-processing program, and the introduction is returned to the trainee. The trainee then reviews and accepts or rejects the edits. Once the introduction is complete, the trainee continues with the materials and methods section.

Materials and Methods

Construction of the materials and methods section simply follows the steps of the research project. Details begin with IRB approval, how the cases were selected, and the inclusion and exclusion criteria. Statistical analysis methods are also described. Actual numbers are not included at this point, because they are considered results and therefore appear in the results section [11].

Results

The first paragraph of the results section provides the demographic information about the study group. If a reference standard is used in the project, it is helpful to indicate to the reader in this first paragraph how many subjects had positive as opposed to negative findings. For example, one could state, "Of the 100 subjects, 90% (90/100) had a meniscal tear at arthroscopy, and the other 10% (10/100) had normal menisci." The numerator and denominator are included with every percentage.

In the results section of a manuscript on a retrospective study, the second paragraph typically describes in detail the results of the retrospective review. Reference is made to figures that show examples of the imaging findings. It is often helpful to include a table listing the data, including percentages, the numerators and denominators used to calculate the percentages, and the *p* values. A specific journal may prefer the results in either text or table format to avoid redundancy, although use of a table alone is helpful for meeting word count requirements. The next paragraph provides the results of the statistical analysis.

Discussion

The discussion section of the manuscript provides a succinct summary and interpretation of the results section. The first paragraph should be four or five sentences that describe the project in a nutshell. The second paragraph may detail the anatomy or pathology of the topic for the reader. A third paragraph details what has been described in the literature on the topic. It is similar to the second paragraph of the introduction but contains more detail, highlighting any shortcomings, to focus the reader on the importance of the current research project hypothesis.

The fourth paragraph of the discussion summarizes the results in a different context or perspective for the reader instead of simply restating the results. The most important results are emphasized, and the results are interpreted with explanations for the results and discussion of whether the results proved or disproved the original hypothesis.

The next paragraph in the discussion describes the limitations of the study, such as sample size, selection bias, retrospective review, consensus review, lack of interobserver or intraobserver variability assessment, and verification bias [12]. When acknowledging a limitation, one should counter the limitation with a statement explaining why the limitation could not be avoided.

The last paragraph of the discussion is the summary or conclusion, typically two or three sentences. The first sentence should be a concise statement that emphasizes the essential points of the project. The next sentence describes the implications of the study, and the last sentence may address the need for future studies.

References

The use of a software tool to manage the bibliography saves time and decreases errors during editing. Internal institutional education and other resources may be available to assist with specific reference software programs. More important than the number of references is the quality of the references, especially those that are pertinent and recent. Several review-type references should be included in the introduction so that the reader has a resource for an overview of the topic. It is vital to repeat literature searches throughout the process so that the bibliography is current.

Images and Figure Legends

Images for the manuscript are usually selected by the mentor and saved as a high-quality file in a format such as TIFF. According to guidelines for the specific journal, images are cropped and formatted to the proper resolution and size, and arrows and other labels are added. Arrows should not be so large as to distract the reader. Shadowing of the labels helps by making the labels more conspicuous. The selected images should summarize the most important findings of the project.

Abstract, Title, and Authorship

The abstract is a condensed version of the entire manuscript and written according to specific journal guidelines. The conclusion sentence should be concise and similar to, if not same as, the first sentence in the conclusion paragraph of the discussion. The title page is completed and shows the authorship order described earlier.

Coauthor Review

There are two methods for coauthor review of the manuscript. If the primary author believes that the manuscript is essentially ready to be submitted, then the manuscript can be sent to all coauthors at the same time to expedite the process. The coauthors can

be requested to use track changes and send back any edits or comments. We provide a strict deadline of 10–14 days to review and edit the manuscript. When a manuscript needs additional work and substantial input from a specific coauthor, the manuscript can be sent to that person first, the edits incorporated, and the subsequent version forwarded to the coauthors simultaneously.

Conclusion

Mentoring a trainee in the completion of a retrospective research project is an ideal way to introduce academics to a trainee. We have provided our perspective on this process as it pertains to a retrospective research project with the expectation that some of these points can assist both trainees and mentors in their success.

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APPENDIX 1: Project Commitment Worksheet

Project Idea

Date:

Mentor:

Mentee:

Relevance/hypotheses:

Time commitment:

Educational Exhibit

Title:

Abstract deadline:

Meeting date/location:

Paper Presentation

Title:

Abstract deadline:

Meeting date/location:

Article

Title:

Final deadline:

(Appendixes continue on next page)

APPENDIX 2: Project Preparation

Project Title _____

Authorship _____

Preparation

Project Preparation Checklist Item	Yes	No	Deadline Date	Comments
Literature search	☐	☐		Search engines
Hypothesis	☐	☐		Relevance
Study design development	☐	☐		
Statistician	☐	☐		Name E-mail
Power study	☐	☐		Number needed
Institutional Review Board (IRB) application	☐	☐		Date submitted
IRB application approval	☐	☐		Approval date Approval no.
Meeting with coauthors	☐	☐		Date Time Location

Education Exhibit

Exhibit Checklist Item	Yes	No	Deadline Date	Comments
Authorship	☐	☐		Order
Theme	☐	☐		
Meeting	☐	☐		
Accepted	☐	☐		
Radiology media services notified	☐	☐		
Materials submitted	☐	☐		
Coauthor review	☐	☐		
Poster or exhibit finalized	☐	☐		
MedEd portal submission	☐	☐		

Project Title _____

Authorship _____

Scientific Project

Planning/Process Checklist Item	Yes	No	Deadline Date	Comments
Subject search	☐	☐		Search engines Total number
Search criteria	☐	☐		
Preliminary spreadsheet	☐	☐		
Password/encryption	☐	☐		
Preliminary spreadsheet review	☐	☐		No. of cases
Revisions	☐	☐		
Spreadsheet complete	☐	☐		No. of cases
Statistical analysis	☐	☐		
Results analysis	☐	☐		

(Appendix 2 continues on next page)

APPENDIX 2: Project Preparation (continued)

Project Title _____

Authorship _____

Manuscript

Planning/Process Checklist Item	Yes	No	Deadline Date	Comments
Standards for Reporting of Diagnostic Accuracy review	☐	☐		
Journal submission	☐	☐		
Introduction	☐	☐		Paragraph 1. Sentence 1. Why relevant Sentence 2. Brief background Sentence 3. Why completed/hypothesis Paragraph 2. Brief literature review Paragraph 3. Why completed/hypothesis
Materials and methods	☐	☐		IRB approval How selected? Inclusion criteria Exclusion criteria Statistical analysis methods
Results	☐	☐		Demographics Results fraction and percentage Reference to images Table
Discussion	☐	☐		Paragraph 1. Project summary Paragraph 2. Anatomy/pathology of topic Paragraph 3. Previous literature (more details than introduction paragraph 2 and focus on shortcomings) Paragraph 4. Summarize results in new context Paragraph 5. Disprove/prove hypothesis Paragraph 6. Limitations/how to avoid Paragraph 7. Summary Sentence 1. Take-home point Sentence 2. Implications Sentence 3. Need for additional studies
Images and figures	☐	☐		Journal specifications Labeled Annotated
Abstract	☐	☐		Word count
Coauthor 1 review	☐	☐		E-mail
Coauthor 2 review	☐	☐		E-mail
Coauthor 3 review	☐	☐		E-mail
Coauthor 4 review	☐	☐		E-mail
Final review				
Submission				
Accepted				Publication date Revision date