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The Art of Scientific Writing: How to Get Your Research Published!

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Abstract

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The purpose of this article is to provide potential authors with a contemporary guide to scientific writing. It is in essence a handbook that covers the planning for a scientific publication from inception of the project or study to manuscript preparation and, ultimately, acceptance by a journal. Major topics such as manuscript formatting, data analysis, use of charts, graphs and images, reference formats, and manuscript submission are presented.

Keywords: Scientific writing, writing guidelines, manuscript preparation, reference formats

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Introduction

"Publish or perish." We've all heard or read those words as they relate to promotion and tenure for individuals in academia. Unfortunately, scientific writing and "research" may not have been part of every clinician's formal training. Consequently, these same individuals have to develop their research knowledge and refine their writing skills. They may collaborate with a more experienced faculty member, take a writing course, or otherwise find their own way through the process.

This publication was created to share our experiences in scientific writing and subsequent manuscript preparation. We'll take you from article inception to manuscript preparation and, ultimately, with good fortune, acceptance by a journal. In this way you will fast familiarize yourself with all phases of what can become a lengthy process. A key to successful results is acquiring an understanding of how the process works before you actually begin a study or prepare your first manuscript draft. Please recognize that this information is a reflection of our opinions. Your actual experiences may vary.

We hope you'll find scientific writing both fulfilling and professionally rewarding as you share your discoveries with the dental profession.

Getting Started

Whether you conduct a clinical study, undertake a bench top laboratory project, or review the literature, we recommend you pursue a project that truly interests you. From start to finish expect to devote a substantial amount of your "free" time to this endeavor, so be patient and don't try to rush the process.

It is also quite possible your time commitment may actually increase once the research is underway. Quite often unforeseen events and unanticipated changes arise that delay even the best of studies. Be flexible, patient, and learn to cope with the unexpected.

Define Roles

In all likelihood you will collaborate with other faculty members or fellow students. It will benefit all concerned if you define individual roles before starting your study or experiment. If you are new to the process, you may want to actually assign roles to delineate who will do what and when. This may prevent confusion and avoid future problems.

Set a Timetable

Regardless of where you are in a research effort – designing the study, making specimens, testing specimens or evaluating cases, analyzing data, writing the manuscript, or reviewing a completed manuscript, you'll find it helpful to establish a deadline for each task. Create a timetable and deadlines for every step in the process right through publication. There have been occasions when second and third drafts of very publishable work have languished on someone's desk, left forgotten in a stack of papers, or filed away in one author's desk simply because there was no timetable or deadline in place. More importantly, no one was monitoring the process.

Choose an Appropriate Journal[1, 2]

Deciding where to submit your completed manuscript is a very important step and one to weigh heavily. A poor choice here may result in frustration and problems, if the manuscript has to undergo review by more than one journal. Rejection may require manuscript revisions to conform to the style and format requirements of a second journal. Such a situation may result in months of delays.

Journal formats differ so widely you could be required to reduce the abstract to a specific number of words, convert tables to graphs, decrease the overall number of illustrations (photographs and figures), change the way the conclusions are presented, reformat the references, and so on. With luck these revisions may be modest at best. More than likely, reformatting an article will be complex enough that one author should make the required changes to ensure the subsequent submission is formatted correctly for the second journal. The revisions may be too extensive to convey this task to an administrative assistant or secretary.

Insight on where to submit your paper may surface while preparing the literature review. Often one or two journals stand out as frequent publishers of articles related to your

research. In that event carefully scrutinize the most recent publications to determine which journal best targets the audience for whom you are writing, then discuss this decision with your coauthors for their views.

Formatting the Manuscript[3]

Once the decision has been made as to where you would like to have work published, obtain a copy of that journal's instructions, often referred to as "Author Guidelines." If you can't find this information in the back pages of a current issue, visit the journal's website and download the guidelines.

Print and photocopy the instructions so each author has an opportunity to acquaint him/herself with the intended format and style. One individual intimately familiar with the project should assume responsibility for preparing the first draft of the paper. Alternatively, that senior author could ask all coauthors to write a specific section of the manuscript (review of the literature, materials and methods, discussion, conclusion, statistical analysis, the abstract, the list of references, etc.). Everyone can prepare an assigned section with a copy of the Author Guidelines close at hand. The senior author can then put all the sections together, edit each part for consistency in writing style, and create a draft that adheres to all the journal's requirements.

As often happens, one individual invariably assumes responsibility for the entire project. The coauthors merely read and comment on each section of the manuscript while in draft form. Either way, that one person has to champion the project and enlist the input and counsel of the others.

If everyone works at his or her own pace, the manuscript may take longer to complete. Some authors will finish their assigned task in a prompt fashion, while others will require repeated reminders even to have their material in "draft" form by an agreed upon due date. A collaborative effort is needed by all parties to ensure success.

Authorship[4]

This may seem like a minor point, but the listing of authors and the order in which their names appear are often taken for granted. Decide who will be the primary author, who should be listed as coauthors, and the order in which each name should appear.

For primary authorship, it is probably prudent to assign the first author position to the investigator who conducted the bulk of the research or who was in charge of spearheading the project. In other words give first authorship to the person who deserves it the most. After that, the order of appearance is quite subjective. You may wish to rank the research participants in their order of importance or significance to the project. Bear in mind when the published article is cited in the literature, it may very well appear simply with the name of the first author or the first three authors followed by the words "et al." (for example, Smith et al. or Smith, Jones, and Winter et al.). So weigh your selection of the first author carefully.

Once the first author has been chosen, arrange the remaining authors in order of their involvement in the project. Be mindful someone can be listed as an author who was not directly involved in your experiment or study per se but played a major role interpreting your data and writing the manuscript.

For example, in an article on tooth whitening in a leading dental journal, seven (7) people appeared as authors. The senior author apparently chose to include everyone who had some role in the study, literally everyone. Alternatively, he could have listed just the two or three people who ran the study and used the Acknowledgment section to recognize those individuals who helped make the project possible. There are choices to be made every time you write for publication. A frank discussion initially as to whom you will or will not include as an actual author and whom to recognize in Acknowledgments will prevent misunderstandings later.

Data Analysis[5, 6, 7]

After colleting the raw data, the next step is to perform the statistical analyses. Then make an appointment with a statistician to discuss the data and analyze your findings. Armed with the raw data, statistical analyses, and assessment of the outcomes, you are ready to interpret the results.

What do your outcomes indicate? Did your research support existing and previously published findings? Were the results contrary to present thinking or did they shed new light on an old subject? In other words what did it all mean?

Don't merely focus on the data and say Group 1 was better than Group 2 or Group 1 had higher sheer bond strength values than the other test groups? Ask yourself what conclusions can be drawn from these findings. How might those conclusions influence your thinking or use of a material you studied? If you conducted a pilot study say so, but don't extrapolate beyond what is appropriate.

Writing the Manuscript – *The First Draft*[8]

As mentioned previously, you can have several individuals write the different sections of the manuscript or one author can take on the entire task. Regardless of how you approach it, the most challenging first step may be preparation of that initial draft.

If you don't already have your own approach to scientific writing, try this. Start at the very beginning of the paper and write whatever comes to your mind just to get something down on paper (on computer). Have as your goal the creation of a completed first draft. If successful, you give yourself a framework to refine and revise. Never mind that you don't like the organization or you think the phrasing may be awkward or unclear. That's fine for now. At least you have thoughts on paper. Those words can always be rearranged later by you, your fellow authors, or an outside party with more writing experience.

Avoid the temptation to ask someone for help armed only with your protocol, raw data, and statistical analyses but no manuscript. You may want to hand everything over to a more experienced faculty member and say "Here, can you turn this into a manuscript?" But it is very difficult for an individual not directly associated with the project to transform a protocol and statistical data into a finished manuscript. In fact it may require an inordinate amount of time. That third party not only does not know anything about your study (except what appears in the protocol), but the subject matter may be quite foreign to him/her.

Hand that same person a manuscript in draft form, and your request takes on a different meaning. Now you are asking someone with writing experience to review the paper, comment on the science, and make editorial suggestions to improve the writing. That's a task someone not intimately involved in your project would more likely agree to do for you.

Tips for Manuscript Preparation

The following are some tips for preparing a manuscript:

General Format Requirements: The specific requirements will probably vary from journal to journal. Yet, it is safe to say most editors will expect the following:

1. The manuscript to be double-spaced
2. Printed on 8" x 11" paper (or ISO A4 sized paper) with one inch margins
3. Printed on one side only
4. All pages must be numbered (see the author guidelines for the exact location)
5. Table, graphs, legends, and reference lists should each be on separate pages
6. Three (3) to four (4) complete copies of the manuscript (including all supporting documents) with a PC-compatible copy on diskette
7. The manuscript should be written in a common software program (Microsoft Word or WordPerfect). Some journals may ask for a specific program, such as Microsoft Word.
8. Have all the authors sign a Copyright Release or Transfer of Copyright form.
   (**Note:** Some journals may not require

a transfer of copyright agreement (or release) with your initial submission. It is only after your manuscript has been accepted for publication that you will be asked to have all authors sign and submit a Copyright Release. Other journals ask only the primary author to sign the release on behalf of all the authors.)

9. Include a transmittal (cover) letter signed by the corresponding author

Abbreviations: We are all accustomed to abbreviating lengthy names or descriptions in both our spoken and written language. But in scientific writing, with first mention you should write out the full name and put the abbreviation in parenthesis. Two examples would be the American Dental Association (ADA) and an analysis of variance (ANOVA). Remember, to some readers ADA might mean the American Disabilities Act rather than the American Dental Association. Once these names have been properly identified, you can use the abbreviations ADA and ANOVA in subsequent sections of your manuscript.

Title Page[9]: As a general rule, you should expect to prepare a title page with the following information:

1. The title of the article (make it concise, yet descriptive)
2. The names of all the authors (first, middle, and last name)
3. The highest academic degrees of each author
4. Department and affiliated institution or name of business (non-academic authors)
5. E-mail addresses for each author
6. Identify the source(s) of any funding or financial support for research related to the article
7. Name, address, phone number, and fax number of the corresponding author
8. Do not put author(s) names(s) on individual pages of the manuscript, just the title page

Introduction[10]: In this section of the paper your goal is to introduce readers to the subject under study and state why you did what you did. State questions/issues you wanted to evaluate in greater detail. Carefully select references to support those statements.

If a journal requires a null hypothesis, you could include that as the last sentence of the Introduction.

Materials and Methods[10]: In this section you will portray your experiment in great detail, outlining how you made specimens, tested specimens, evaluated failures, examined and scored patients, and so on. Think of this as a "tell all" section where you have the duty to describe your experiment/study well enough that someone might be able to reproduce the study, if they wished to do so. Some journals instruct authors to list product names, manufacturers (city and state), and lot numbers in a table. It is often helpful to include photographs or line drawings to illustrate how you made, tested, or evaluated items in the study.

Statistical Analysis[5, 6]: Name the statistical tests you used to evaluate the data and specify the probability level. (**Note:** In some journals the Statistical Analysis is included in Materials and Methods, while in others it appears as a separate section between Materials and Methods and Results.)

Results[7]: Briefly describe all outcomes using tables and/or figures to graphically present the results. This portion of the paper may be brief because your goal is to state the results and not to discuss or explain your findings. Check the journal guidelines for specifics. Some publications don't want you to put the raw data (means and standard deviations) in a table but prefer you use graphs (with standard deviations). You may feel the data are easier to interpret if presented in a table. However, journal guidelines may require the information be presented differently.

Tables, Graphs, and Photographs: These elements of any well-written paper often allow readers to determine quickly if the rest of the article is worth reading. The effort required to produce easy-to-read tables and graphs is time well spent. Here are a few suggestions:

Tables: This presentation of data is often the heart, or better yet, the brains of a scientific paper. Five key components of a well-prepared table are: title, column headings, row headings, the field, and explanatory notes (when

necessary). If you have very little data to present, consider including them in the text. Keep the table content simple and avoid cramming a lot of information into a small space. Make the tables easy to read, round numbers to no more than two decimal points, and include the probability value (such as P<0.05). Use Arabic numerals (1, 2, 3…) or symbols (such as * and #) to identify explanatory notes.

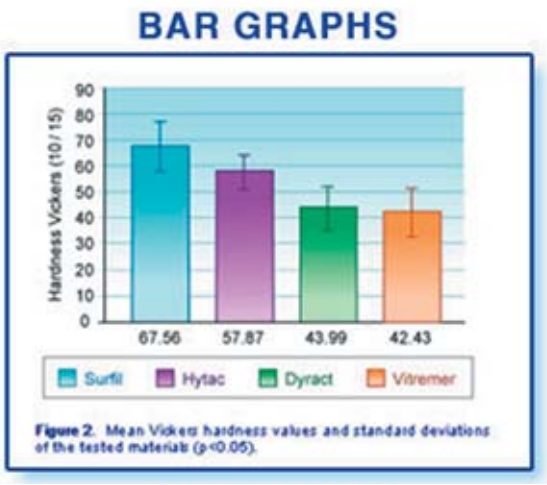
Graphs: You would include a graph to illustrate a trend or relations between variables rather than simply publish the raw data. Bar graphs, histograms, pie charts, line drawings, and scatter graphs are very common. These illustrations allow you to visually display relative comparisons and trends over time.

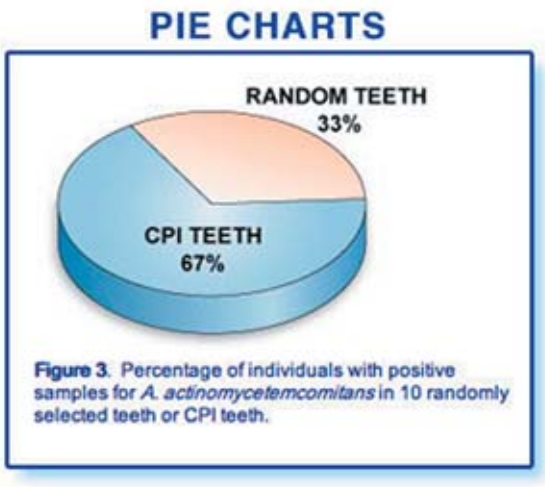
Use several colors to facilitate the visual interpretation of your results, especially when comparing different treatments or the same treatment over several time intervals. Good color selection allows readers to visually separate items in the graphs. Label each graph so it can be readily understood what information is being presented.

Photographs: If you intend to include photographs of patients, obtain written consent from them otherwise you will have to conceal their identity (masking the eyes is not always enough). Plan ahead if you wish to include clinical photographs in the article. (**Note:** A journal editor may ask you to pay for the cost of publishing color illustrations, so budget accordingly.)

Scanning Electron Micrograph (SEM) Photographs: Should you wish to illustrate findings or outcomes with SEMs, include labels so the magnification is included in each photograph. If appropriate, also consider inserting a measurement scale to help readers interpret what is depicted in each SEM.

(**Note**: Write a concise, but descriptive legend for every figure, illustration, and photograph.)





Discussion[12]**:** This is the section of a manuscript where you discuss how and why you obtained the results you did. Use the Discussion section to explain the outcomes and assess the findings of your investigation. Mention how the results compared to other published reports. Did the findings agree with or differ from previously published articles? Use references to support statements and avoid making unsubstantiated claims or interpretations.

One common mistake is restating the numerical results in the Discussion. Don't merely say Product A had significantly higher shear bond strength than Product B or XYZ underwent less linear dimensional change than ABC. Readers (as well as editors and reviewers) want you to explain the outcomes. Why was the shear bond strength higher for Product A, and why did ABC have less linear dimensional change? Give your interpretation of what happened and explain why you believe you obtained these results. Support your statements with references from related published reports.

Aside from the Abstract, the Discussion may be one of the more difficult sections of a manuscript to write. You should not only present a clear interpretation of the study results, but you must also demonstrate familiarity with the body of knowledge published on this subject.

Conclusions and Clinical Implications (*if included*)[13]**:** Write concise statements (conclusions) that can be supported by the study's data and outcomes. Do not overreach when drawing conclusions. In other words, if you conducted a laboratory, bench-top project, it would not be appropriate to make sweeping clinical conclusions.

Study data should support the conclusions and vice versa. It is also important for each author to read the manuscript with great care and attention. Don't assume every conclusion is correct simply because the paper was prepared by a more experienced faculty member or writer. Are the conclusions convincing to you based on the study findings?

People make mistakes, and the more time spent on a manuscript the more likely you are to overlook errors that are readily discernable to others reading the work for the first time. It is extremely important each author reviews every draft not only to ensure the science is correctly reported but that the manuscript is formatted properly. In other words don't simply verify that all the references are cited and the figures and tables are linked to the correct sentence. Do that and more. Critique your discussion and conclusions. Did you discuss your outcomes relative to other published reports in the Discussion section and not simply regurgitate the numerical values you already reported in Results? Ask yourself if the data were reported correctly? Were the conclusions appropriate given the results obtained and the type of study conducted?

Furthermore, don't draw sweeping conclusions from a bench test or recommend a change to clinical procedures based on a study of 10 specimens of one product in the laboratory. But do tell readers what you think is significant about your findings. Mention what additional research, if any, may need to be pursued based on your study. Incorporating this type of analysis will strengthen the paper in the eyes of any reviewer.

Clinical Implications: Several journals require you to include a Clinical Implications statement at the close of the Abstract.

Abstract[1, 14, 15]**:** The word abstract is derived from the Latin, *ab = from* and *tractus = to draw* away. So the abstract should select (*draw out*) the highlights of each section of your paper. You may find it helpful to draft the abstract after writing the entire manuscript when you've completed a few revisions. Remember the guidelines for the abstract differ from journal to journal. Acquaint yourself with the requirements for the publication you've selected. Adhere to those guidelines, and try to write a crisp description for each section. Use the "word count" feature of your word processing software to ensure the abstract is in compliance with the journal's length requirement. Remember the purpose of the abstract!

References[16]**:** It will be especially helpful if you update your references *before* you submit the final manuscript. In some instances a substantial

amount of time elapses from the time you initiated your project to the time you finished the work. It is strongly recommended you conduct another literature search to identify any relevant reports or articles published since your last search. If you do not do this, the reviewers will probably note the absence of current references and lower their rating of your paper accordingly. So be preemptive and address this issue yourself.

You should select references that are directly related to your project and include current publications. Make certain the references are cited correctly. One of the most common publishing mistakes is citing references that actually have nothing to do with an article's content. Sometimes references are cited in article after article because they were listed as references in previously published, and often cited, journals. New authors then assume these references were appropriate and directly related to their manuscript's content. To avoid this mistake, obtain a copy of every article or abstract you wish to use as a reference. Review the text, and make certain each article is cited correctly in your manuscript.

The three common reference styles are: name and year, alphabet-number, and citation order. Examine the journal guidelines for the specific style requested for submissions and use that format.

Writing the Manuscript – *The Editing Process*

Writing is an endeavor some people enjoy but others dread. Regardless of which category you fall into, editing is the key to successful writing. After preparing a first draft, put the manuscript aside for a few days or pass it on to coauthors for their comments and suggestions. Tell the coauthors you're giving them a first draft, a work in progress if you will. When you next read that draft, you'll take a "fresh" look at it and, undoubtedly, see items you'd like to add, eliminate, or simply revise.

Before making any editorial changes take a moment to review the "Author Guidelines" of the journal to which you plan to submit the completed manuscript. Next, revise the Abstract after making all your initial changes to the body of the paper. When you do tackle the Abstract, you merely have to condense the text you've already finalized. That should make the task much easier.

Carefully review your paper from Introduction to Conclusion. Examine every sentence and each word in those sentences. Revise the text to express your thoughts in the fewest words possible. If you can eliminate words without changing your thoughts, then do so. Avoid word repetition – using the same nouns or verbs in close proximity. However, you can repeat key points if you think it would be meaningful. Bear in mind page space in journals is limited and editors appreciate brevity. One goal should be to refine the writing, so the text flows smoothly from sentence to sentence and paragraph to paragraph.

The key to successful writing may be the process of editing. You continue to revise your ideas until they are expressed as succinctly as possible. The probability of acceptance for publication is greatly enhanced if the submission is not only sound scientifically but well written and concise.

If you and your coauthors are not native English speakers and writers, have someone review your paper that is fluent in English. Journals are more likely to accept your work if your submission is easy to read and understand. Reviewers are more apt to reject a manuscript that does not read well and is not well organized.

Writing the Manuscript – *Your Final Review*

Once you and your fellow authors have a finished product, perform a final manuscript review for compliance with the "Author Guidelines." Closely scrutinize each page of the manuscript to ensure strict adherence to the guidelines. Reviewers are more likely to interpret formatting errors and poor writing as negative first impressions.

Pay attention to the details. Make certain the manuscript is written in one of the recommended fonts (Arial, Times New Roman, etc.) and font sizes (12 or 10 point). Are the page margins and line spacing correct? Are the references in the proper format? Are the figures and tables appropriate for the journal? Are the legends for the figures and tables concise so they stand

alone? Is the Abstract the appropriate length and does it contain the correct headings? These are just a few of the questions you should ask yourself. Use your responses to make any final changes. Don't submit your manuscript if you know it is not properly formatted. Do your best to adhere as closely to the journal's recommended format as you can with your initial submission.

Submitting the Manuscript to the Journal [1, 2, 3]

The "Author Guidelines" will specify how to submit the manuscript (number of photocopies and electronic format). If the journal has a checklist, use it to ensure your mailing is complete.

Remember, the corresponding author should write a cover letter to the editor and include it with the manuscript and supporting documents. Make certain you have duplicate copies of *every* part of your manuscript: text, graphs, tables, drawings, illustrations, photographs, pictures, SEMs, and so on. It does not happen often but on occasion submissions get lost in the review process. In that event the corresponding author will receive a polite, but apologetic, letter from the editor requesting resubmission of specific parts of the paper. Be prepared in the event this happens to you.

The vast majority of manuscripts and accompanying documents arrive safely and are reviewed without incident. Typically, a journal will send the corresponding author a letter acknowledging receipt of the submission. If you do not receive such a letter in a reasonable amount of time, consider contacting the journal editor. Don't assume all is well until you have some written assurance from the journal.

Online Submissions: A growing number of journals now either permit or require the electronic submission of manuscripts to simplify the review process and overall management of vast numbers of manuscripts. Whenever possible, include a "Return Receipt" request so you know your manuscript has not been lost in cyberspace.

Revising the Accepted Manuscript

After the paper has been through the journal's review process, you can expect one of three decisions: (1) acceptance, (2) acceptance with a request to make revisions, or (3) rejection.

If you submitted a well-written manuscript to the right journal, it is not unreasonable to expect your work to be accepted for publication. However, it is also highly likely the editor will ask you to make revisions he/she and the reviewers suggested based on the reviews. Share the cover letter and reviewers' comments and recommendations with your coauthors, and then revise the manuscript as soon as possible. With your resubmission include another letter to the editor outlining how you've addressed the concerns/recommendations of the reviewers.

Dealing with "Rejection"

Let's face it. More articles are submitted to journals than can possibly be published at any one time.[17] You need to be prepared to face the inevitable "rejection" letter. Don't be discouraged because the journal editor should provide you with a cover letter containing the reasons for the rejection and possibly some recommendations for improving your manuscript.

Take that guidance and use it to revise the manuscript. Then consider submitting it to another journal. Don't give up. Perseverance can pay off.

Proof Reading

The last step before actual publication will be for you to review your article, as it will appear in the journal. Years ago proofs, or page mockups, were sent to the corresponding author for a final review of the article. This was so typesetting errors could be corrected and editing changes could be identified and made.

Today, you are more likely to receive an electronic version of your article via e-mail than a mailing of proofs. Nonetheless, the process is the same. You closely examine the electronic form of your article comparing it to your final submission. Look for errors, make corrections, and do any last minute editing. Proceed carefully with this review because the next time you see your paper it will be in print.

Examples of Reference Formats for Specific Journals

From the Journal of the American Dental Association (JADA):

Li Y. Tooth bleaching using peroxide-containing agents: current status of safety issues. Compendium 1998;19:783-96.

From the American Journal of Dentistry:

Thornton JB, Retief DH, Bradley EA: Marginal leakage of two glass ionomer cements. Ketac-Fil and Ketac-Silver. *Am J Dent* 1988;1:35-38.

Compendium:

Becker W, Berg L, Becker BE: Untreated periodontal disease: a longitudinal study. *J Periodontol* 59(5):234-244.

From the Journal of the California Dental Association:

White SN, MacEntee MI et al. Restorative treatment for geriatric root caries. *J Cal Dent Assoc* 22(3): 55-60, 1994.

From the Journal of Contemporary Dental Practice:

Crumble OM, Spitzle DJ, Grover NP. Loss of gingival attachment in the presence of accretions. J Dent Anom 1997;45:130-142.

From the International Journal of Prosthodontics:

Lin M-T, Sy-Muñoz J, Muñoz CA, Goodacre CJ, Naylor WP: The effect of tooth preparation form on the fit of Procera copings. *Int J Prosthodont* 1998;11:580-590.

From the Journal of Prosthodontics:

Harris RJ: The connective tissue and partial thickness double pedicle graft: A predictable method of obtaining root coverage. J Periodontol 1992;63:477-486.

For Abstracts, Chapters in Books, and Reports:

Refer to the guidelines for each journal for the format requirements.

(**Note:** As can be seen in the examples listed above, some guidelines call for journal titles to be italicized while others do not.)

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