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Writing for the *Journal of Orthopaedic Research*

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Good scientific writing requires good science and good writing. Unfortunately, the last time most of us were asked to think about the mechanics of writing was in grade school. As a result, many of us have forgotten the rules of grammar, the weakness of the passive voice, and the need for topic sentences and transitional phrases in the construction of a paragraph. In addition, few of us have been taught to write a scientific manuscript. Instead, we learn by emulating available (and sometimes imperfect) literature and by the slow and often painful process of writing and publishing our work. Furthermore, of the many texts and articles about scientific writing, few deal in practical terms with the form and content of biomedical research papers. Thus, when planning to publish our research results, we can be faced with a series of questions. What should be included in the Introduction? How much literature should be reviewed? How many reference citations are too many? What order should be followed and what tense should be used in the Materials and Methods section? How should figures be cited in the Results section? How should the Discussion be organized? What constitutes a good title? What should be covered in the summary?

When an article is being written for a particular journal, especially one like the *Journal of Orthopaedic Research* that has two editorial offices, questions of format and style can be even more confusing. If different editors expect different editorial style, published manuscripts may exhibit stylistic differences that further confuse authors trying to model their papers on recent issues of the journal. The consequence is all too often the submission of manuscripts that do not conform to a particular editorial vision, even if they reflect good science and writing. This can result in author frustration, delays in resubmissions, and extra cycles of review. Moreover, especially with first-time authors, the editors must write editorial decision letters that repeat the same writing guidelines again and again.

One of the most distinctive features of the *Journal of Orthopaedic Research* is its multidisciplinary readership. Readers vary considerably in their level of knowledge concerning the structure and function of the musculoskeletal system. Some readers have in-depth knowledge of one musculoskeletal tissue but not of others. For example, most experts in articular cartilage know little about skeletal muscle. Similarly, we have readers from a wide range of specialties, including orthopaedic surgery, biology, biochemistry, and bioengineering. Although an orthopaedic surgeon may not have detailed knowledge of finite-element modeling, he or she might be interested in reading a study that uses such an analytical tool to answer an important research question about implant performance. Authors need to consider the unique readership of the Journal and write so that scientists and clinicians with different backgrounds easily understand their manuscripts.

With this essay, we hope to provide some practical advice about editorial content. We also hope to articulate our collective editorial vision of good scientific writing and of a reasonable but flexible set of guidelines for manuscripts submitted to the *Journal of Orthopaedic Research*. We think it reasonable for our readership to expect that manuscripts published in the Journal represent not only the best of science but also the best of scientific writing. We do not, however, intend to impose a rigid conformity on submitted manuscripts. Instead, we would like to suggest a set of minimum standards for editorial content and a framework that helps ensure that these standards are met. These rely in part on Zeiger's *Essentials of Writing Biomedical Research Papers* (5), an excellent text that we highly recommend for writers of all levels of skill and experience. We will focus on the more common results type of paper, in which the author describes an experiment that was performed and the new results that were obtained. More information on how to write a methods paper, in which the author describes a new method, material, or apparatus, can be found in Ms. Zeiger's book. We hope that this essay continues to

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evolve in response to your own comments and suggestions and that it contributes to better scientific writing and more rapid publication of your work in the *Journal of Orthopaedic Research*.

WORDS, SENTENCES, AND PARAGRAPHS

Good writing requires that we think logically, that we say what we mean, and that we say what will be understood. The Council of Biology Editors (3) has proposed four rules of writing: Rule 1, be simple and concise; Rule 2, make sure of the meaning of every word; Rule 3, use verbs instead of abstract nouns; and Rule 4, break up noun clusters and stacked modifiers.

Perhaps anticipating Rule 1, Pascal wrote, "I have made this letter longer than usual, because I lack the time to make it short." The same holds for good scientific writing. As you write, ask, What can be shortened or simplified? What can be eliminated? Keep in mind that every word that does no good, does harm. This does not mean that every sentence should be short or that details should not be included. It does require that every word "tell" (2). Compare "Optimal reaction conditions are approximated when..." with "The reaction goes fastest when..." The first phrase could also be interpreted to mean "The action goes most nearly to completion when..." Simple language also enforces accurate thinking. By being verbose, we are often inaccurate. One of the best ways to examine the logic of a line of reasoning is to express it in the simplest possible terms. This technique can be used to examine the train of thought in an introduction, the construction of a paragraph, or the number of words in a phrase. If you can say it more simply, do so.

With respect to Rule 2, make sure that every word aims at precision of meaning. Rigorous application of this simple idea not only increases accuracy of thought but also helps eliminate many of the common grammatical errors found in scientific writing. Writing about orthopaedic research is full of complex words, and the complexity increases as we expand into the fields of biochemistry, molecular and cellular biology, engineering, genetics, and clinical epidemiology. However, if the main objective of our writing is to be understood, we must use such words with great care. If simpler words are equally descriptive and make the text more accessible to a multidisciplinary readership, then simpler words should be used.

Rule 3, use verbs instead of abstract nouns, is directed toward restoring vigor to scientific writing. Verbs express action. If the action of a sentence is expressed by the main verb, the sentence is natural, direct, and easy to understand (5). If the action is instead expressed by a noun, object, or prepositional phrase, the sentence is often hazy and more difficult to understand. Compare "An increase in heart rate occurred" with "Heart rate increased." Compare "The new drug caused a decrease in heart rate" with "The new drug decreased heart rate." Sentences are more likely to be simple and direct if the subject, verb, and object convey the core of the message. To ensure that they do, make the topic the subject of the sentence and put the action in the verb. To find action that is not in the verb, look for weak verbs such as "occurred," "showed," "caused," "produced," "was achieved," "was observed," and "was noted." Also, look for nouns made from verbs, with endings such as "tion" (inhibition, formation, and decomposition), "ment" (measurement and assessment), "ence" (occurrence and existence), and "al" (removal). Abstain from using "increase" and "decrease" as nouns instead of verbs. Avoid vague qualifiers such as "markedly," "fairly," "quite," "rather," "several," "very," and "much"; these can usually be omitted or should be replaced with specific quantitative information.

Rule 4, break up noun clusters and stacked modifiers, relates to the use of one noun to modify another. Examples include "heart rate," "bone cell," and "protein concentrations." However, addition of another noun or nouns to an already existing noun pair can be confusing. Compare "trabecular length variability" with "variability in trabecular length." The problem is compounded when an adjective is added to the noun cluster (5). In the phrase "chronic sheep experiments," it is unclear whether the sheep or the experiments are chronic. The meaning is clear when you break up the noun cluster and use "chronic experiments in sheep." It can be even more confusing when the noun that the adjective modifies is omitted from the noun cluster altogether. In the sentence, "To correct for zero drift, we used a calibration phantom," does "zero drift" mean no drift? The meaning becomes clear if this is written, "To correct for drift of the zero point, we..." A useful rule of thumb is to allow clustering of two nouns but not the addition of a third noun or modifier to the two-noun cluster. To correct for noun clusters and stacked modifiers, decide on the precise relationship between the modifiers and express this relationship by inserting prepositions and verbs.

Besides the four rules, there are other suggestions to consider. Make sure that the antecedents of the pronouns are clear (5). The antecedent is the word to which the pronoun refers. In the sentence "Laboratory animals are not susceptible to these diseases, so research on them is hampered," it is unclear whether "them" refers to "these diseases" or "laboratory animals." The sentence could be revised to read "Laboratory animals are not susceptible to these diseases, so research on these diseases is hampered." You could also say "Research on these diseases is hampered because laboratory animals are not susceptible to them."

Avoid jargon, acronyms, and abbreviations (4). Such terms can save space and provide immediate recognition (for example, use of ACL for anterior cruciate ligament); however, without appropriate definitions, they can confuse the reader. Limit your use of the latest jargon and be sure to define acronyms and abbreviations the first time they appear in the text to aid the reader who may be interested in your work but unfamiliar with your field.

With respect to sentence structure, short sentences are easier than long ones to understand. Long sentences that string ideas together, talk about two ideas at once, or nest one idea inside another are particularly difficult to read. In general, to avoid overloaded sentences, keep them as short as possible. A rough guideline is to have an average sentence length of about 22 words or fewer. In papers that have especially dense scientific content, short sentences are particularly important. The more difficult the science, the simpler the writing should be (5).

Even if words are carefully chosen and sentences are appropriately constructed, manuscripts can be difficult to understand if the paragraphs are not clearly organized. Each paragraph should be constructed to tell a story. For a paragraph to tell a clear story, the ideas in the paragraph must be organized and relationships between the ideas must be clear (5). The most direct way to impose an organizational structure on a paragraph is to use a topic sentence. A topic sentence gives an overview of all other sentences by stating the message of the paragraph. Supporting sentences say something specific about the subject introduced in the topic sentence. A typical topic sentence might be "Three different mechanisms may be responsible for the remodeling of trabecular bone." Supporting sentences would then go on to explain the three mechanisms.

The pattern of organization for supporting sentences is crucial to constructing a logical argument. If the order is anticipated in the topic sentence, it should be followed in the rest of the paragraph. If no order is anticipated, one option is to proceed from the most to the least important supporting sentence. To ensure that the reader knows you are talking about the same things in the supporting sentences as in the topic sentence, new terminology should not be introduced. Instead, repeat key terms exactly. If the topic sentence indicates a parallel structure, the same parallel structure should be followed in the supporting sentences. The introduction of extraneous material should be avoided, and gaps in the argument should be eliminated. Transitional words can be powerful indicators of logical relationships. Examples include "therefore" (conclusion), "because," "for example," "first" (sequence), and "however" and "although" (contrast). Transitional words and phrases that link sentences should usually come at the beginning of the sentence to indicate the logic of the idea that is to follow.

Just as sentences should be short and not overloaded with information, paragraphs should be as short as possible and consistent with a clear description or argument. Take every opportunity to omit unnecessary detail and repetition, either by eliminating words or full sentences.

THE TEXT OF A RESEARCH MANUSCRIPT

A major problem with many of the manuscripts submitted to the *Journal of Orthopaedic Research* is their density of information. Too many include rambling and exhaustive surveys of previous literature, endless lists of tabular data, and meandering and disorganized discussions. As a result, the boundaries of current knowledge are not defined, the research question is never posed, and a clear message does not emerge. We aim to publish short, incisive papers that tell a clear story and answer an important research question. In some cases, there is no such story and the manuscript is better left unwritten. In others, part of what has been done does not contribute to the story and is better omitted. The point is not to publish all that has been done but instead to publish only what is good science and answers an important question. Negative results often meet these criteria. If a negative finding is good science and important, it should be published because it may save others from repeating experiments or may indicate new questions or new strategies to address those questions.

The four traditional sections of a biomedical research manuscript are designed to ensure that a coherent message emerges. The Introduction summarizes what is known, defines what is unknown or problematic with the known, and ends with a statement of the objectives or research questions being addressed. The Materials and Methods section is a chronological description of what was done to address the question and should end with a paragraph describing the experimental design and statistical analysis of the data. The Results section presents the results, ordered from most to least important. The Discussion begins with answers to the research questions, followed by supporting evidence that includes strengths and limitations of the experiment, comparisons with previous studies, and a statement of the implications of the findings. To help ensure that a coherent message emerges, think of each section in relation to the research question: the Introduction states the question, the Materials and Methods section describes the experiments done to answer the question, the Results section reports the results found, and the Discussion answers the question (5).

Introduction

The Introduction (Fig. 1) is designed to awaken interest in the topic and to provide enough information

INTRODUCTION

Establish the importance of the subject.

⇓

Explain what is known.

⇓

State what is unknown or problematic with the known.

⇓

Conclude with a clear statement of the research questions.

FIG. 1. Introduction.

so that specialists and nonspecialists can understand the paper and judge the importance of its findings. As with other sections, the Introduction should be as short as possible. For a typical Journal manuscript, one typewritten page (about 250 words) is usually sufficient. When more extensive background information is required, the Introduction should still be limited to no more than two typewritten pages (about 500 words).

One way to begin the Introduction is with a sentence or two of background information that places the subject matter in context and helps define the importance of the problem. For a paper on the biomechanics of anterior cruciate ligament reconstruction, for example, you might indicate how many anterior cruciate ligament injuries occur annually, how many are treated surgically, and what the outcomes are. In our increasingly cost-conscious society, the associated costs are also of interest because their magnitude may help define the potential savings associated with a new or improved technique.

Zeiger (5) suggests that the Introduction should be viewed as a funnel, narrowing step by step from what is already known to what is unknown and then to a statement of the research question. Thus, after the introductory background material, the usual starting point is a paragraph with a topic sentence stating something known about the subject matter. A recent discovery or a long-held assumption about the field is a typical starting point. As an example, you might begin with the topic sentence, "Several factors, collectively known as Wolff's Law, are thought to control remodeling of trabecular bone." The remaining sentences of the paragraph, with appropriate citations to the literature, would then explain these factors.

The statement of what is known should be followed by a sentence stating what is unknown or problematic with the known. An example might be a shortcoming with the way in which the data in the literature were obtained. For the example in the previous paragraph, you might write, "However, previous attempts at providing a mathematical formulation for Wolff's Law have been made in the absence of accurate methods for characterizing the three-dimensional architecture of trabecular bone." The statement of what is unknown or problematic with the known should lead directly to the statement of the research question. The language used to describe what is known and unknown should anticipate the research question, and the question itself should follow inevitably from the unknown. If the manuscript addresses more than one question, the questions should be listed in decreasing order of importance and each should follow from the previous descriptions of what is known and unknown.

The descriptions of what is known and unknown should include references chosen to reflect the key literature that forms the background for the paper. Keep the number of references to a minimum. In the Introduction to a research manuscript, an exhaustive literature review is not needed. Instead, you should include the most recent and important papers. If the field is extensive, review articles can be cited. Generally, we ask that authors limit literature citations to about 25 for the manuscript. Also, avoid excessive use of author names when you refer to previous literature. The logical flow is generally clearest if the focus is on the "science, not the scientists" (5).

The end of the Introduction, which defines the research question or questions, is perhaps the most important part of the manuscript. If the research questions are clearly and explicitly articulated, the reader will understand why the experiments were conducted and will know what answer to expect. There are a number of ways to signal the research question. One way is to begin the last paragraph of the Introduction with a statement of general goals, followed by a sentence that lists the research questions in decreasing order of importance. For example, "We undertook this study as a first step toward formulating and testing a damage-based theory for remodeling of trabecular bone. Specifically, we addressed the following research questions: (a) does trabecular damage during *in vitro* cyclic loading occur in locations predicted by microstructural models for anisotropic cellular solids and, if so, (b) does the extent of damage, characterized by the number and length of cracks, vary with stress magnitude or number of loading cycles, or both?"

You can also state the research question as an objective, followed by the experimental approach: "To determine the location and extent of trabecular fatigue damage, we counted cracks and measured crack lengths after subjecting waisted, cylindrical specimens to cyclic loading *in vitro*." Many other phrases can be used to signal the question: "Therefore, our purpose was..."; "Thus, we asked whether..."; "Therefore, our first objective was to..."; and "As a first step, we asked whether...." "Whether" implies alternatives and usually leads to a stronger statement of the research question than when "if" is used. The number of research

MATERIALS AND METHODS

Materials: What was examined?

Methods: What was done to answer the questions? (= protocol)

⇓

Why was it done? (= purposes)

⇓

How was it done? (= methods)

⇓

How was it analyzed?

FIG. 2. Materials and Methods.

questions that should be addressed is limited. Only rarely should more than two or three questions be addressed in a single manuscript.

With regard to tense, the general rule is to use the present tense for statements that are currently true, e.g., "It is known that cracks occur...," and the past tense for what you or others thought or did in the past, e.g., "In previous studies, we examined..." The question is generally signaled in the past tense, e.g., "Our purpose was...," but the questions themselves should always be stated in the present tense. The writing is also generally more lively if the first person pronoun "I" or "we" is used. Compare "This experiment was designed to test the hypothesis..." with "In this experiment, we tested the hypothesis..."

Materials and Methods

The Materials and Methods section (Fig. 2) should tell the reader what you did and what materials, agents, and devices you used to answer the research questions posed in the Introduction. Enough detail should be provided so that another scientist can evaluate the credibility of your work and repeat the experiments as you performed them. This explanation can often be quite long and include different types of information, so consider dividing the Materials and Methods section into subsections on the basis of the type of information. Within subsections, topics should be organized either chronologically or in the order of most to least important. For example, in describing the steps taken to prepare specimens for testing, chronological presentation makes the most sense. For a subsection dealing with protocol or experimental design, however, the independent and dependent variables should be described in the order of most to least important.

Visual signals should be used to show the organization of the Materials and Methods section. Visual signals include subheadings, new paragraphs, or new sentences. For example, a topic sentence can give an overview of all the other sentences in the paragraph: "Using an animal model, we examined the effects of blunt trauma to the patella on the histology of the underlying articular cartilage." The reader knows the remainder of the paragraph will include more details about the model and the methods for creating the trauma and performing the histological observations. A transitional phrase can also be effective in introducing a topic, e.g., "To prepare specimens for testing, we first removed the spinous processes..." The initial phrase alerts the reader that what follows will describe the protocol for specimen preparation.

For materials, give a detailed description of what was examined (materials, cells, bones, animals, and human subjects). Include the source, generic name, composition, and manufacturer for materials, agents, and devices. For animals, describe the species, weight, strain, gender, age, and any other information germane to the research question. Similarly, for human subjects, include age, gender, race, height, weight, medical condition, and medical or surgical management. For experiments that involved animals and human subjects, state that the research was approved by the appropriate approval committee at your institution.

For methods, give a detailed explanation of what was done. Describe the protocol by stating what manipulations were performed to cause a change (the independent variables) and what measurements or observations were made to assess the changes brought about by the manipulations (the dependent variables). Include a description of the controls of the independent variables (if any) that were included in the study. Consider relating the protocol directly to the research question by restating the question at the beginning of the protocol, e.g., "To determine the effects of stress magnitude and number of loading cycles on the extent of damage in trabecular bone, we counted cracks and measured crack lengths after subjecting waisted, cylindrical specimens to cyclic loading *in vitro*."

Explain why the method was used. What was its purpose? It is sometimes difficult for the reader to understand why a particular procedure was used, so provide a brief justification for procedures that do not clearly relate to the research question or to other procedures in the experiment. Describe what specific methods were performed and what equipment was used to perform the manipulations and to measure or observe the resulting changes.

End the section by explaining how the data were analyzed. Include the statistical methods used to draw inferences from the data and the level of probability assumed to represent a statistically significant difference.

A number of other guidelines should be considered in writing the Materials and Methods section. Cite pertinent literature. References to accepted, previously published procedures can shorten the presentation and refer the reader to valuable information. Describe the methods in past tense. Avoid presenting results in the Materials and Methods section. The only exception is the presentation of intermediate results to justify a procedure or to provide information necessary to obtain other results that answer the research question.

A final caution is that you should include a complete presentation of the materials and methods. Currently, many articles submitted to the Journal describe research on the efficacy and application of new products or procedures intended for commercial distribution. The authors often have financial relationships with the company developing the product. Indeed, such relationships can be beneficial to the rapid development of important new treatments. Conflicts can arise, however, between the competitive, financial interests of the authors and the complete description of what was used and what was done in the experiment. Papers published in the Journal must include a complete description of the methods. The description should include the sources of materials with the names and locations of the companies or individuals who provided them, information about how materials or instruments necessary to repeat the experiment can be obtained, and methods used to analyze the results (1). Failure to report a complete description compromises the credibility of the report and of the Journal (1). Ultimately, the authors are responsible for ensuring that sufficient detail is provided.

Results

The Results section (Fig. 3) should provide the results of the experiment and refer the reader to the data that support the results. Results and data are not the same. A result is a stated message, e.g., "more cracks were observed in stained sections from the specimens that had been subjected to the higher number of load cycles." Data are numbers that support results and are best presented in tables or figures, e.g., a bar chart of the number of cracks counted in specimens subjected to a number of different load cycles. Although raw data can be presented, it is usually more informative to use statistical summaries (e.g., means and standard deviations) or to transform the data (e.g., as a percentage of the control values). It is unnecessary to present all the data from an experiment; provide only those that bear directly on the research question. Avoid including comparisons with results from other studies. Such comparisons should instead be included in the Discussion.

Results should usually be presented in the same order as the research questions posed at the end of the Introduction, from most to least important. Some experiments are best described chronologically. However, if a chronological order places important results at the end of the section or detracts from emphasizing the study design, consider organizing the results in order of most to least important. Present the results that answer the research question first. Describe secondary results that provide further support, but that are not crucial to the answer, after presenting the more important results.

RESULTS

Present results in decreasing order of importance (or chronologically), following the research questions at the end of the introduction.

Avoid figures or tables as the subjects or objects of sentences.

Do not duplicate data in the text, figures, and tables.

State the major results in the text; refer to figures and tables parenthetically; avoid including data in the text.

FIG. 3. Results.

Topic sentences for paragraphs in the Results section should be strong, declarative sentences that describe results. Avoid using methods as topic sentences. Such topic sentences tend to repeat what the reader has already learned from the Materials and Methods section and detract from the importance of the result. Be sure all pertinent results are stated explicitly in the text of the Results section. Do not rely on the reader to infer an important result from data in figures or tables. Instead, state the result and refer the reader to the data (usually by a parenthetical reference to a figure or table) so that the result and the supporting data are linked. Avoid using figures or tables as subjects or objects of sentences. They contain data and, therefore, are of secondary importance to the results. Authors are often tempted to state data in the text and to present the same data in a table or figure. It is best to preserve the text for results and relegate data to tables and figures.

Compare "The strains in the proximal cortex ranged from compressive to tensile (Table 1). When the stiffer stem was in place, strains in region 1 went from -2347 ± 423 to -1415 ± 379 microstrain (Fig. 3). This difference was statistically significant ($p < 0.05$)" with "Stem stiffness decreased the compressive strains measured in the most proximal region. When the stiffer stem was in place, compressive strains decreased by almost 40% compared with when the compliant stem was in place (Table 1)." The former example has a weak topic sentence that does not clearly state a useful result (no clear statement of results is apparent anywhere in this example). Data are included in the text, repeated in a table, and then repeated again in a figure. The results of a statistical analysis are presented, but the meaning and magnitude of the difference are unclear. In contrast, the latter example begins with a strong result that could be considered an answer to a research question posed earlier in the paper. Data supporting the result are appropriately relegated to a table. Also, in the latter example, the reader is not required to go through a decoding step to remember the location of region 1, a step that is at best disruptive. Instead, the region is more explicitly described.

Although a detailed discussion of figures and tables is beyond the scope of this presentation, there are some important considerations for preparing graphs, photographs, and tables. Remember that the size of figures will probably be altered as part of the publication process. Therefore, choose large font sizes for lettering on graphs and other figures and large symbols for data points. Place magnification markers directly on microphotographs so that the magnification remains accurate when the photograph is reduced or enlarged during publication. Avoid using three-dimensional graphs unless the third dimension represents a variable being examined. Be sure to include appropriate error bars (usually standard deviations) in graphs that display summary data. Lines on graphs should represent statistically determined curves fitted through the data.

A useful technique to assess both the organization and completeness of your paper is to check that every question posed in the Introduction has an answer in the Results section and that every result has a method in the Materials and Methods section that describes how the result was reached. This ensures that all necessary and pertinent information (and no extraneous information) is included in the paper. There is a tendency to consider the Results section as the core of the paper and therefore to put more into the section than is required. The Results section should be concise and written in a manner that directs the reader to the important questions that you were trying to address.

DISCUSSION

Restate the research questions.

⇓

Describe how your data support the answers to the questions.

⇓

Establish what is new and important by comparing your findings with those of others.

⇓

Present the strengths and limitations of your study.

⇓

End with a clear statement (e.g., the implications of your findings) or with speculations based on the answers to your questions.

FIG. 4. Discussion.

Discussion

The primary function of the Discussion (Fig. 4) is to answer the research question. This section should begin, therefore, with a rephrasing of the question, followed by the answer that was reached from the results of the experiment. The answers should be explicit and direct. A second function of the Discussion is to explain how the results support the answer. Methods and results should not be repeated. Rather, the Discussion should focus on the question that you intended to answer and how the results lead to your answer. Consider referring to key data in figures or tables to remind the reader how the results were reached from the data. Remember that you are telling a story centered on the research question. The Discussion is where you bring together all aspects of the study so the reader can grasp the big picture.

Another function of the Discussion is to explain how the answer compares with existing knowledge on the subject. This is best done by comparing your answer with the work of others (with appropriate references to the literature). Does your answer fit with current thinking? Can you explain conflicts or discrepancies between your results and those of others? What new information is provided by your answer that complements or contradicts previous work? Such comparisons help focus on what is important about your work.

In considering what is new and important about your work, provide the reader with a balanced presentation of the strengths and limitations. Strengths can come from several sources, including the experimental design (such as the use of appropriate control samples or the elimination of potential bias through randomization and blinded assessments). Most experiments have weaknesses. These should be discussed so that the reader can appreciate the limitations of your work. Perhaps your experimental design had weaknesses (such as uncontrollable sources of bias). You may have made certain assumptions within the experimental methods or analytical techniques that limit the relevance of your conclusions. Explain why you believe that such shortcomings are acceptable.

The Discussion should end with a clear statement. This could be a restatement of the answers to the questions and an indication of the implications of your findings, possible applications of the results (e.g., in some clinically relevant way), or speculations based on the answers. Avoid ending the Discussion with a statement of future studies. Your future plans are not part of the story.

Overview Sections

We want to close by touching briefly on two important aspects that are intended to present the reader with an overview of the paper: the summary and the title. The summary should present the main story with only a few essential details. It should follow the same organizational framework that is used elsewhere in the manuscript. Begin with a sentence or two of background information to establish the topic and justify the research question. Next, state the research question, or questions, in the same order as that used in the last paragraph of the Introduction and in the Results section. Briefly describe what was done to answer the question, the results, and what the answer was. Finish with a statement or two underscoring the implications of the work. Remember that the goal is to provide an accurate summary and clear preview of the paper to attract readers.

The title should identify the main topic of the paper. This is usually the topic of the research question or hypothesis. For a paper reporting the results of an experiment, the title should be a phrase that includes the controlled independent variable, or variables, the observed or measured dependent variable, or variables, and the material, species, or model that was studied. Often, the results of an experiment are unequivocal. In these cases, consider using a sentence title (the present tense and active voice). For example, compare "Effects of Local Injection of Growth Factor on Healing of Segmental Bone Defects" with "Local Injection of Growth Factor Stimulates Healing of Segmental Bone Defects." Papers do not always report an experiment. For a methods paper, for example, it is helpful if the title distinguishes whether a method, a piece of equipment, or a material was developed and then states its purpose. A good title is concise and unambiguous, serving to attract readers to further explore the article.

We hope the advice that we have presented in this article is useful. We look forward to receiving your manuscripts for publication in the Journal.

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