Association between study design and citation counts of articles published in the American Journal of Orthodontics and Dentofacial Orthopedics and Angle Orthodontist

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Objective: The scientific community views meta-analyses and systematic reviews, in addition to well-designed randomized controlled clinical trials, as the highest echelon in the continuum of hierarchy of evidence. The objective of this study was to examine the association between different study designs and citation counts of articles published in the American Journal of Orthodontics and Dentofacial Orthopedics and Angle Orthodontist. Methods: All articles, excluding editorial comments, letters to the editor, commentaries, and special articles, that were published in the American Journal of Orthodontics and Dentofacial Orthopedics and Angle Orthodontist during the years 2004 and 2005 were examined in this study. The number of times an article was cited in the first 24 months after its publication was computed. The PubMed database was used to index the study design of the articles. The association between study design and citation counts was examined using the Kruskal-Wallis test. A multivariable negative binomial regression model was used to examine the association between citation count and study design along with several other confounding variables. Results: A total of 624 articles were selected for analysis. Of these, there were 25 meta-analyses or review articles, 42 randomized clinical trials, 59 clinical trials, 48 animal studies, 64 case reports, and 386 quasiexperimental/miscellaneous study designs. The mean ± SD citation count was 1.04 ± 1.46. Nearly half of the articles (n = 311) were not cited even once during the observation period. Case reports were cited less frequently than meta-analyses or reviews (incident risk ratio, 0.37; 95% confidence interval, 0.19 to 0.72; P = .003), even after adjusting for other independent variables. Conclusion: Among various study designs, meta-analyses and review articles are more likely to be cited in the first 24 months after publication. This study demonstrates the importance of publishing more meta-analyses and review articles for quicker dissemination of research findings. ORTHODONTICS (CHIC) 2012;13:184–191.

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Published studies are increasingly used to disseminate the latest developments in science and are widely used for clinical decision making. One measure of assessing the usefulness of a published article is citation count (the number of times an article is referenced in other published articles).\(^1\),\(^2\) Despite their purported limitations,\(^3\) citations do provide an indication of how scientifically relevant a work is to further research\(^4\) in a related area or topic of interest and are often considered hallmarks of academic achievement.\(^5\),\(^6\) There is a paucity of published studies examining the factors associated with citation counts in the field of orthodontics. Such reports can shed evidence on the type of studies that are likely to have a significant impact on progress of science. It is viewed in the scientific community that meta-analyses and systematic reviews, along with well-designed randomized controlled clinical trials, occupy the highest echelon in the continuum of hierarchy of evidence compared with quasiexperimental study designs, case series, and case reports.\(^7\)–\(^9\) It may be possible that citation count patterns follow the hierarchy of evidence. We hypothesized that there is a difference in citation counts in orthodontics literature based on the study design.

The objective of this study was to examine the association between different study designs and the citation counts of published articles. The citation count for the first 24 months after publication was calculated, and its association with study design was examined.

METHODS

Article selection
We examined all articles (excluding editorial comments, letters to the editor, commentaries, and special articles) that were published in the American Journal of Orthodontics and Dentofacial Orthopedics and Angle Orthodontist during 2004 and 2005. The number of times an article was cited in the first 24 months after its publication was the outcome variable. For example, an article
published in the January 2005 issue of American Journal of Orthodontics and Dentofacial Orthopedics was followed until December 2007, and the number of times this article was cited during this period was counted. Information regarding the number of times an article was cited was obtained from the Web of Science—Science Citation Index.¹⁰

Two independent reviewers retrieved the articles. The PubMed database was used to index the study design of each article. Each article was classified as a meta-analysis/review article, randomized clinical trial, clinical trial (not randomized), quasiexperimental/miscellaneous study design, animal study, or case report.

**Independent variables**
The primary independent variable of interest was the study design. The published articles were classified as outlined above. We also examined the association between other variables (including number of authors, number of references used in the published article, geographic region, and funding source) and the first 24-month citation count. With regard to geographic region, the country of study origin as indexed in the PubMed database was used. Since there were more than 30 countries from which the articles originated, we broadly categorized the articles based on continents (North America, South America, Europe, Asia, Africa, and Oceania). Information regarding funding source was obtained by reviewing the articles as well as the PubMed database. Articles were classified as being US government supported, non-US government supported, and nonfunded studies.

**Statistical approach**
Data distribution was examined by using descriptive statistics, and a one-sample Kolmogorov-Smirnov test was used to examine the normality of distribution of the outcome data (first 24-month citation count). The outcome data were not normally distributed (P < .001), and nonparametric tests were used to examine the association between the outcome and independent variables of interest. The Kruskal-Wallis test was used to examine the association between number of citations and study design. The results suggested that there was a significant difference in the number of citations among the different study designs. Multiple post hoc tests using the Mann-Whitney U test were used to examine the differences between the different study design groups. Multiple testings introduce the possibility of type 1 error; to account for this issue, Bonferroni corrections were used. Considering that there were six study design groups, and a total of 15 post hoc comparisons were to examine differences among all the groups, P < .0033 was deemed to be statistically significant (two-tailed tests) for the post hoc comparisons. The association between the number of citations and continent of origin was also examined by the Kruskal-Wallis test, and further similar post hoc testings were performed. The association between the number of citations and funding source was also examined, and post hoc comparisons were made since the Kruskal-Wallis test revealed statistically significant differences among different funding sources. Association between the number of citations and authors was examined using Spearman rho correlation coefficients. A multivariable regression model was used to examine the association between the 24-month citation count (outcome variable) and all independent variables. Since the number of citations is count data and the data were highly skewed, a multivariable negative binomial regression model was used to simultaneously examine the association between citation counts and all independent variables. All statistical tests were two-sided, and P < .05 was deemed to be statistically significant (except where post hoc multiple comparisons were made as mentioned earlier). Statistical analyses were conducted using SPSS 16.0 (IBM) and STATA 8.0 (STATA).
RESULTS

A total of 624 articles were selected for analysis. Of these articles, there were 25 meta-analyses/review articles, 42 randomized clinical trials, 59 clinical trials (excluding randomized clinical trials), 48 animal studies, 64 case reports, and 386 quasiexperimental/miscellaneous study designs (including observational studies, cross-sectional studies, and retrospective studies). The descriptive statistics of the selected articles are summarized in Tables 1 to 3. Out of the 624 articles, 12 were funded by the US government, while 107 were non–US government funded, which includes funding from foreign countries and private organizations.

The mean ± standard deviation (SD) number of citations during the observation period (24 months after publication) was 1.04 ± 1.46. Nearly half of the articles (n = 311) were not cited even once during the observation period. Meta-analyses/review articles were the most frequently cited (mean, 1.48 ± 1.67; median, 1) followed by randomized clinical trials, animal studies, clinical trials (excluding randomized clinical trials), quasiexperimental/miscellaneous study designs, and case reports (see Table 3).
The values from the post hoc multiple comparison Mann-Whitney U tests (following the Kruskal-Wallis test) examining the association between the number of citations and study design are summarized in Table 4. The results from these analyses suggest that there is a statistically significant difference in the number of citations between the different study designs even after adjusting for type 1 errors (by Bonferroni corrections). Case reports were cited less frequently than meta-analyses/reviews, clinical trials (nonrandomized), randomized clinical trials, and animal studies (P = .001).

With regard to the study origin, the Kruskal-Wallis test revealed statistically significant differences in 24-month citation counts among the different continents (P = .003). The results of the post hoc multiple comparisons are summarized in Table 5. The results indicated that there is a significant difference in
citation counts between articles originating from North America (mean citation count, 1.27) and South America (mean citation count, 0.50) \( (P = .001) \), between South America and Europe (mean citation count, 0.97) \( (P = .001) \), and between South America and Oceania (mean citation count, 2.50) \( (P = .004) \).

With regard to funding source, the Kruskal-Wallis test revealed a statistically significant differences in the 24-month citation counts among the different funding sources \( (P = .007) \). Results of the post hoc multiple comparisons are summarized in Table 6. The results indicated that there is a significant difference in citation counts between articles funded by non–US government sources (mean citation count, 1.27) and nonfunded studies (mean citation count, 0.96) \( (P = .003) \).

The Spearman rho correlation coefficients for the number of citations and of authors was 0.097 \( (P = .016) \).

The results of the multivariable analyses are presented in Table 7. Results from the multivariable negative binomial regression model indicated that case reports were cited less often than meta-analyses/reviews (incident risk ratio, 0.37; 95% confidence interval, 0.19 to 0.72; \( P = .003 \)) even after adjusting for other independent variables.

**DISCUSSION**

The current study examines the association between study design and the number of citations in the first 24 months after publication of articles published in two top-tier orthodontic journals (American Journal of Orthodontics and Dentofacial Orthopedics and Angle Orthodontist). The study results suggest that meta-analyses/review articles were cited more frequently in the first 24 months after their publication compared with case reports. This underscores the importance of meta-analyses and review articles for quicker and wider dissemination of scientific knowledge. Our results are consistent with other studies examining factors associated with citation counts.\(^11,12\) Bhandari et al\(^12\)
examined factors associated with citation rates in the orthopedic literature. Following a review of 137 articles, they found that meta-analyses are cited more often than observational studies and case reports. Patsopoulos et al.11 examined the relative citation impact of various study designs in the health sciences. They reviewed a sample of 2,646 articles and found that meta-analyses were cited significantly more frequently than any other type of study design.

Our study examined the association between citation counts and study design for two journals in the field of orthodontics. There are several other journals in orthodontics. Consequently, our study results cannot be generalized to the entire field of orthodontics. Several studies have shown that the impact factor of a journal is one of the strongest predictors of citation counts.2,13 Among the orthodontic-specific journals, three journals had an impact factor in 2008: American Journal of Orthodontics and Dentofacial Orthopedics, Angle Orthodontist, and European Journal of Orthodontics (1.442, 1.166, and 1.015, respectively).10 It should be noted that the specific aim of the current study was to delineate the role of study designs on citations counts, and this study accomplishes this. Including published articles from several other journals would have made the results more generalizable. However, it would have introduced biases arising from clustering of outcomes within journals, and the models would not have converged to yield meaningful incident rate ratio estimates. In addition, it is not clear if the effects of study design on citation counts are dissimilar in other orthodontic journals.

The observation period used for the current study was the 24 months after publication of the article. This observation period was chosen because impact factors are calculated based on this time period, and this exposure period was normalized for all the articles in the current study. It should be noted that this observation period is short, and articles do tend to be cited beyond 2 years after their publication.14 Different journals in which our selected articles have been cited have widely varying lag times from acceptance of an article to actual publication. However, since the observation period was the same for all study designs included in the current study, we do not expect this to highly affect the current study findings and bias the results.

An important issue to consider is that there is usually a lag time between an article's acceptance and publication. There is also considerable amount of time involved in conducting the study and submitting the study findings to journals. The lead time from the stage of conception of the idea to its eventual publication could be 2 years or more. Consequently, the study findings may not reflect the current trends. This issue should be taken into consideration when interpreting the scientific relevance of a study.

In our study, we examined only the relative impact of different study designs on citation counts and did not examine the association between quality of a study and the citation counts. One could assume that well-designed studies have higher citation counts compared with poor-quality studies. However, prior reports across several specialties have shown that the quality of a published article is not associated with citation counts.15,16

We examined the role of several independent variables on citation counts. Information on these variables was available by querying the PubMed database and also by reviewing the article. The possibility of omitted variable bias should not be underestimated, and all results presented in the current study should be interpreted while keeping this in perspective since several confounders not captured in the current study can influence citation counts.
CONCLUSION

Among various study designs, meta-analyses and review articles are more likely to be cited in the first 24 months after publication. This study underscores the importance of publishing more meta-analyses and review articles for quicker dissemination of research findings.

REFERENCES


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