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The top 100 papers in dry eye – A bibliometric analysis

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ABSTRACT

Purpose: Citation analysis represents one of the best currently available methods for quantifying the impact of articles. Bibliometric studies list the "best sellers" in a single field of interest. The purpose of the present study was to identify and analyze the most frequently cited papers in dry eye research that may be of high interest for researchers and clinicians.
Methods: We reviewed the database of the Institute for Scientific Information to identify articles published from 1900 to September 2016. All dry eye articles published in 59 ophthalmology journals were identified. The top 100 articles were selected for further analysis of authorship, source journal, number of citations, citation rate, geographic origin, article type, and level of evidence.
Results: The 100 most-cited articles were published between 1983 and 2011, with most of them in the 2000s. The number of citations per article ranged from 96 to 610, and was greatest for articles published in the 2000s. Each of these articles was published in one of 15 journals. Most articles represented Level-III evidence, followed by Levels II and I.
Conclusions: The present study focusing on dry eye research revealed that 55% of the most-cited articles came from the U.S. and 18% from Japan. Diagnostics and therapy were the areas of focus of most of the clinical articles; 13% of the most cited papers were review articles. This analysis provides researchers and clinicians with a detailed overview on the most cited dry eye papers over the past decades.

1. Introduction

The field of professional scientific publication has undergone seismic evolution in the last decade [1,2]. Almost daily changes make electronic journal submission, publication, and access to periodicals increasingly straightforward [1,2]. Bibliometric sciences offer both a statistical and quantitative analysis of published articles and provide a measure of their impact in a particular field of research [3]. Bibliometric methods allow exploration of various factors, including citation counts and detailed scientific output statistics of single authors, special topics, institutions, or countries [3]. The "impact" of a journal on research can be assessed using the scientific citation index, which is the only available quantitative estimate of a journal's scientific contributions [4–9]. Citation of a work indicates its relevance for its field of interest [10,11]. The impact factor for a journal is a comparative measure of its ranking among journals in a given speciality area. The impact factor is calculated as the number of citations in a given year for articles published in the journal in the preceding 2 years, divided by the overall number of cited articles published in the same 2 years [12,13]. Since the publication of the first article regarding bibliometric methods by Eugene Garfield in the *Journal of the American Medical Association* (*JAMA*) in 1987 [14], this field of information science has continuously evolved [15].

In the field of ophthalmology, visual sciences and optometry, more than 110 periodicals are listed [4]; Thomson Reuters Journal Citation Reports lists 59 periodicals for the category "ophthalmology," of which 52 have a journal impact factor of at least 1.00 or higher [16]. Several bibliometric studies have been published that provide general analysis in the field of ophthalmology [17,18].

Dry eye research has expanded greatly over the past few decades, largely related to new clinically available devices for diagnostics and the introduction of new treatment options [19–21]. Although bibliometric information on special topics in the ophthalmology has been reported, to the best of our knowledge no

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analysis of the dry eye literature has been published [22,23]. In the present study, we identified the most frequently cited 100 articles in dry eye research, using professional scientific databases to access these publications and analyze major journals, origin of publications, and main authors. This enables specialists and new researchers in the field of dry eye to focus on these important articles.

2. Material and methods

Research platforms that provide bibliographic database services are necessary for systematic analysis of publication data. For this study, we used the Institute for Scientific Information (ISI) Web of Knowledge database from the Thomson Reuters Web of Science (WoS) Core Collection. The overall search was conducted in October 2016.

The keywords used for the search were “dry eye” as the “topic” (title, abstract, author's keywords, and KeyWords Plus), a year-of-publication range from 1900 until September 2016, the category “ophthalmology” predefined by the Web of Science, and the document type “articles.” The results were organized from the most cited to the least cited publications. Each search result was reviewed by two independent readers (AF and RK) to ensure its relation to dry eye disease; no paper had to be excluded.

If we found identical numbers of total citations, the more recent articles were ranked higher. The 100 articles with the highest number of citations that matched the search criteria were then analyzed further, again by two independent investigators (MS and AF). Data retrieved included journal name, publication date, first and last authors, year of publication, country of origin, total number of citations for the article, overall citation rate (total citations/article age), current citation rate (measured as the number of citations in the year 2015), research nature (basic science, clinical research or review), and level of evidence according to the 2009 revised Oxford (UK) Centre for Evidence-Based Medicine levels of Evidence (Level 1 to 5; Table 1). Review articles were defined as articles summarizing previously published data and literature. Articles without an identified first author but with shared authorship from different countries were classified as “multinational” origin. (These include chapters from the 2007 Report of the International Dry Eye WorkShop, whose PubMed entries note “No authors listed”).

A limitation of the citation-based searching method is that recent articles with high citation potential may not be captured because they have not had time to accumulate citations. In order to correct for this, a search was performed using the same terms of the main analysis of the highest ranked 100 articles, but using a shorter time period (2015 and 2016).

If there were any discrepancies in the evaluation of the articles between the three main investigators of our study, these were re-evaluated and discussed with a fourth investigator (VD). This method has been utilized in a range of previous publications on bibliometric data [4,13,15].

The Shapiro-Wilk test was applied to test the normality of the distribution of individual variables. We present data that were normally distributed as the mean and standard deviation, and skewed data as the median and the range. The Tukey method was also employed for plotting the whiskers and outliers. The p-values from pairwise t-tests were adjusted according to either the Bonferroni post-hoc test or Mann-Whitney test to correct for the performance of multiple statistical analyses. All p-values were two-tailed, and a p-value of $\leq$0.05 was considered to indicate statistical significance. We used one-way analysis of variance (ANOVA) to test for differences in normally distributed data, and the Kruskal-Wallis test for skewed data. The Spearman rank correlation was employed to test for correlations among non-parametric variables.

3. Results

A total of 3823 eligible publications related to “dry eye” (category “ophthalmology,” document type “articles”) were listed in peer-reviewed journals on the ISI Web of Knowledge WoS Core Collection database (October 2016). Of these, 2.4% (n = 92) had been cited at least 100 times and 0.6% (n = 24) more than 200 times. The publication dates for the 100 most-cited articles (Table 2) were between 1983 and 2011, and the total number of citations per article ranged from 96 to 610. Of the 100 articles, 16 were basic research, 71 were clinical research, and 13 were review articles. Considering the number of citations per type of article, a statistically significant difference was only found between the groups of basic research and clinical research (Mann-Whitney test p = 0.032; basic research: median = 118 [range = 96–266]; clinical research: median = 150 [range = 97–610] [Table 3, Fig. 1]). We subdivided clinical research articles according to topics: diagnostic research (n = 47, 66%), epidemiology (n = 10, 14%), and medical and surgical treatment (n = 14, 20%). Thirteen articles were review articles (mean 189 [range = 105–576]; Table 3). The review articles did not vary significantly with respect to total citations per article compared to the clinical or basic research articles (Fig. 1).

An evidence level of III was assigned to 29 articles in the field of clinical research and systematic reviews (median citations per article 146 [range = 98–438]), followed by IIa (n = 18; median citations per article 162 [range = 109–334]), IIb (n = 11; median citations per article 142 [range = 97–214]), Ib (n = 9; median citations per article 152 [range = 105–610]), Ia (n = 7; median citations per article [range = 126–576]) and IV (n = 4; median citations per article 221 [range = 117–256] (See Table 4 and Fig. 2.). The Kruskal-Wallis Test exhibited no significant differences between number of citations per article and the various levels of evidence (p = 0.216).

Most articles on the list were published from 2000 to 2009 (n = 62), followed by articles published from 2010 to 2016 (n = 6; Fig. 3 A). The total number of citations was greatest for articles published from 2000 to 2009 (mean total number of citations = 179), followed by articles published during the 1990's (mean total number of citations = 166) and those published from

Table 1
Shortened depiction of Oxford Centre for Evidence-Based Medicine 2011 Levels of Evidence. Level may be graded down on the basis of study quality, imprecision, inconsistency between studies, or because the absolute effect size is very small; Level may be graded up if there is a large or very large effect size (based on “Level of Evidence” published online from German Network for Evidence-based Medicine (http://www.ebm-netzwerk.de/was-ist-ebm/images/evidenzklassen.jpg/view. Accessed October 30, 2016)).

Level		Rating Criteria
I	Ia	Evidence obtained from a systematic review of relevant randomized controlled trials (including meta-analysis)
	Ib	Evidence obtained from at least one properly designed randomized, controlled trial
II	IIa	Evidence obtained from at least one well-designed controlled trial without randomization
	IIb	Evidence obtained from one well-designed, pseudo-experimental trial
III		Evidence obtained from a well-designed, non-experimental descriptive trial
IV		Evidence obtained from case reports, expert opinion, consensus conference