Benchmarking the Dental Implant Evidence on MEDLINE

Stephen P. Russo, DMD[1]/Joseph P. Fiorellini, DMD, DMSc[2]/
Hans-Peter Weber, DMD[3]/Richard Niederman, DMD[4]

The purpose of this study was to estimate the quantity of dental implant literature available on MEDLINE for evidence-based clinical decision-making and to identify its location. A search strategy based on Medical Subject Headings for dental implants was developed to examine MEDLINE using the Ovid Web Gateway search engine. Sensitive and specific methodologic search filters identified 4 categories of information: etiology, diagnosis, therapy, and prognosis. The results were then subdivided by year to identify trends and sorted to identify the sources of publications. The searches identified 4,655 articles published in English between 1989 and 1999 on human dental implants on MEDLINE. The mean number of articles (± SD) per year ranged from 15 ± 11 for specific searches to 107 ± 50 for sensitive searches. The number of articles increased by 14% to 43% each year for the sensitive search. When subdivided by clinical category, the mean numbers of articles per year for sensitive and specific searches were, respectively: diagnosis 12 ± 7.5 and 1.5 ± 1.6, etiology 58 ± 33 and 1.9 ± 2.5, therapy 23 ± 15 and 0.3 ± 0.5, and prognosis 67 ± 33 and 12 ± 8.3. Four dental journals account for approximately half of these publications. These results provide 6 key central findings: (1) there appears to be a substantial literature of clinically relevant information on implants upon which to base clinical decisions; (2) the implant literature is significantly biased toward articles addressing prognosis; (3) to stay current, one would need to read between 1 and 2 articles per week 52 weeks per year, and this number increases significantly each year; (4) approximately 50% of the articles were published in 4 journals, whereas the remainder reside in approximately 97 other journals, making it difficult to stay current; (5) these trends reaffirm the need for lifelong learning; (6) these trends also suggest the need for computer-based clinical knowledge systems. (Int J Oral Maxillofac Implants 2000;15:792–800)

Key words: *bibliometrics, diagnosis, etiology, implants, prognosis, therapeutics*

With growing emphasis on the development of evidence-based clinical decision-making, increasing importance is being placed on the availability of high-quality evidence.[1,2] Access to computer-based communication networks and critically appraised medical information on the Internet can potentially improve clinical decision-making by increasing information availability.[3] Evidence-based clinical decision-making, however, requires the presence of, and access to, a large volume of high-quality clinical information.

To identify and verify the availability of dental implant information for evidence-based clinical decision-making, a benchmarking study of MEDLINE was conducted using bibliometric methods. Similar methods have been successfully employed for similar purposes in medicine.[4] Bibliometric analysis methods are currently being used by the U.S. National Academy of Science for evaluating research programs[5] and have been used for evaluating clinical progress in cardiology,[6] audiology,[7] mental health,[8] epilepsy,[9] emergency medicine,[10] diagnostic medicine,[11] allied health,[12] arthritis,[13] and dentistry.[14]

[1]Office of Evidence-Based Dentistry, Harvard School of Dental Medicine, Boston, Massachusetts.
[2]Chair, Department of Periodontics, Harvard School of Dental Medicine, Boston, Massachusetts.
[3]Chair, Department of Restorative Dentistry, Harvard School of Dental Medicine, Boston, Massachusetts.
[4]Head, Office of Evidence-Based Dentistry, Harvard School of Dental Medicine, Boston, Massachusetts; and Head, Office of Evidence-Based Dentistry, Forsyth Institute, Boston, Massachusetts.

Reprint requests: Dr Richard Niederman, Office of Evidence-Based Dentistry, Harvard School of Dental Medicine, 188 Longwood Avenue, Boston, MA 02115. Fax: 617-432-3881. E-mail: rniederman@hms.harvard.edu

The objectives of the current study were to develop and implement MEDLINE search strategies that would access the dental implant literature, and then to estimate the availability of literature that one can potentially use to make clinical decisions and examine trends. In particular, the availability of articles on etiology, diagnosis, therapy, and prognosis was of interest.

MATERIALS AND METHODS

Literature Search

A literature search was developed as follows. From the MEDLINE Medical Subject Headings (MeSH), the vocabulary for dental implants was applied. This included the following terms: blade implantation; dental implantation; dental implantation, endosseous; dental implantation, endosseous, endodontic; dental implantation, osseointegrated; dental implantation, subperiosteal; dental implants; dental implants, single-tooth; and dental prosthesis, implant-supported. Table 1 presents the search strategy used to identify and quantify the implant literature on MEDLINE from the year 1966 through June 2000, week 1. The search was performed using the Ovid Web Gateway Internet interface for MEDLINE (Ovid Technologies, Inc, New York, NY; http://gateway.ovid.com). The identified literature was limited to humans, to articles written in English, and to articles published from 1989 through 1999. Sensitive and specific methodologic filters were then used to identify 4 clinical categories of information: etiology, diagnosis, therapy, and prognosis (Table 2).[15] As used here, *sensitive search* indicates a search strategy that retrieves

Table 1 Implant Search Strategy Based on MeSH, 1966 to June 2000, Week 1

Step no.	Search history	Results
1	exp dental implants/	3976
2	exp dental implantation, endosseous/	5675
3	exp dental implantation/	8473
4	dental prosthesis, implant-supported/	874
5	1 or 2 or 3 or 4	10415
6	limit 5 to (human *and* English language *and* year = 1989–1999)	4655

Table 2 Methodologic Filters Used for Searching

Category	Sensitive search	Specific search
Etiology	1. exp cohort studies/ 2. exp risk/ 3. (odds and ratio$).tw. 4. (relative and risk).tw. 5. (case and control$).tw. 6. 1 or 2 or 3 or 4 or 5	1. case-control-studies/ 2. cohort studies/ 3. 1 or 2
Diagnosis	1. exp sensitivity and specificity/ 2. sensitivity.tw. 3. di.fs. 4. du.fs. 5. specificity.tw. 6. 1 or 2 or 3 or 4 or 5	1. exp and sensitivity and specificity 2. (predictive and value$).tw. 3. 1 or 2
Therapy	1. limit (step 6 in Table 2) to randomized control trial 2. dt.fs. 3. tu.fs. 4. random$.tw. 5. 1 or 2 or 3 or 4	1. (double and blind$).tw. 2. placebo$.tw. 3. 1 or 2
Prognosis	1. incidence/ 2. exp mortality/ 3. follow-up studies 4. mo.fs. 5. progno$.tw. 6. predict$.tw. 7. course.tw. 8. 1 or 2 or 3 or 4 or 5 or 6 or 7	1. prognosis/ 2. survival-analysis/ 3. 1 or 2

MEDLINE abbreviations: .tw. = textword search; .fs. = floating subheading (a subheading attached to any MeSH term in the record). Subheadings: di = diagnosis; du = diagnostic use; dt = drug therapy; tu = therapeutic use; mo = mortality. $ is a "wild card" and can stand for anything.

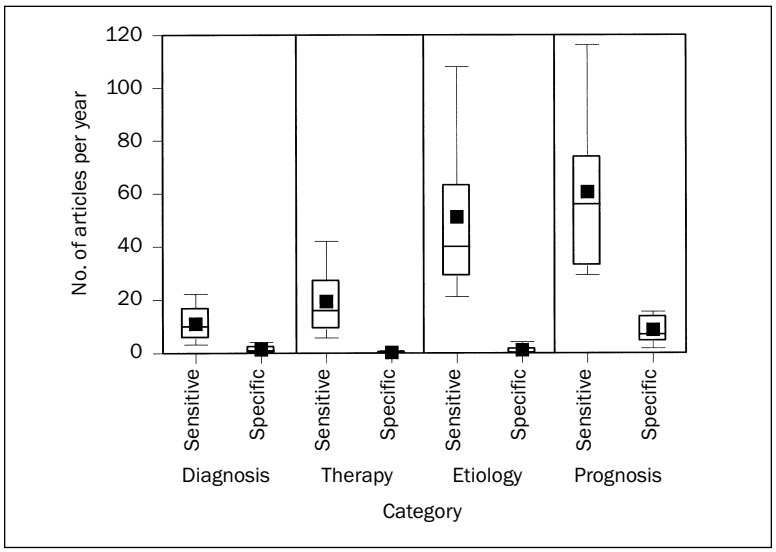

Fig 1 Box plots indicating the number of articles published in 4 clinical categories between 1990 and 1998. The black squares indicate the average, while the horizontal lines indicate the 10th, 25th, 50th, 75th, and 90th percentiles. The graphic displays indicate that sensitive searches identified more articles than specific searches. The etiology and prognosis categories had significantly more articles than diagnosis or therapy in sensitive searches, while the prognosis category had more articles than diagnosis, therapy, or etiology in specific searches.

Table 3 Mean No. of Articles (± SD) Per Year (1989 to 1999)*

Category	Sensitive search	Specific search
Diagnosis	12 ± 7.5 (42%)	1.5 ± 1.6
Etiology	58 ± 33 (43%)	1.9 ± 2.5
Therapy	23 ± 15 (18%)	0.3 ± 0.5
Prognosis	67 ± 33 (14%)	12 ± 8.3
Total	107 ± 50 (29%)	15 ± 11

*Sensitive searches identified significantly more articles than specific searches (all $P < .001$).
Percentages indicate the average percent increase of articles per year.

the largest number of relevant articles but also includes some irrelevant ones. A *specific search* indicates a search strategy that identifies a small number of the most relevant articles but also excludes some relevant articles and most irrelevant articles. The results were then subdivided by year from 1989 to 1999 to identify trends.

The search results were also stratified to identify dental journals that published the greatest number of articles per year in all 4 clinical categories during the past 6 years (1994 to 1999). First, citations for each search type (sensitive or specific) were tallied according to their journal sources. Then, for each search type, the mean number of articles published per year (± SD), the number of relevant citations displayed as a percent of the total number of articles for each respective journal (1994 to 1999), and the number of citations displayed as a percent of the entire subset (sensitive or specific) were calculated. The journals that published these articles were then placed in order, from those that published most to those that published fewest.

Statistical Analysis

The data obtained from the literature search in each category were statistically analyzed using InStat 2.03 for the Macintosh (Graphpad Software, Inc, San Diego, CA). One-way analysis of variance was performed with Tukey-Kramer corrections for multiple comparisons to compare the sensitive and specific search strategies for the 4 clinical topics. Linear regression and the Spearman rank correlation were used to determine differences over time. Within each clinical category, the paired *t* test was used to compare the search strategies.

RESULTS

The results of the implemented search strategy quantify the availability of implant literature. The data (Table 1) indicate that, over the period between 1966 and June 2000, week 2, there were 10,415 articles published on dental implants. Of these, approximately 40% (4,655 articles) were published between 1989 and 1999 (inclusive) in English and addressed human implants.

To determine the number of articles published per year and the distribution of these articles, sensitive and specific methodologic filters were applied (Table 2) to identify those articles addressing diagnosis, etiology, therapy, and prognosis. Figure 1 and Table 3 present summary data for sensitive and specific searches for each of the 4 clinical categories over the

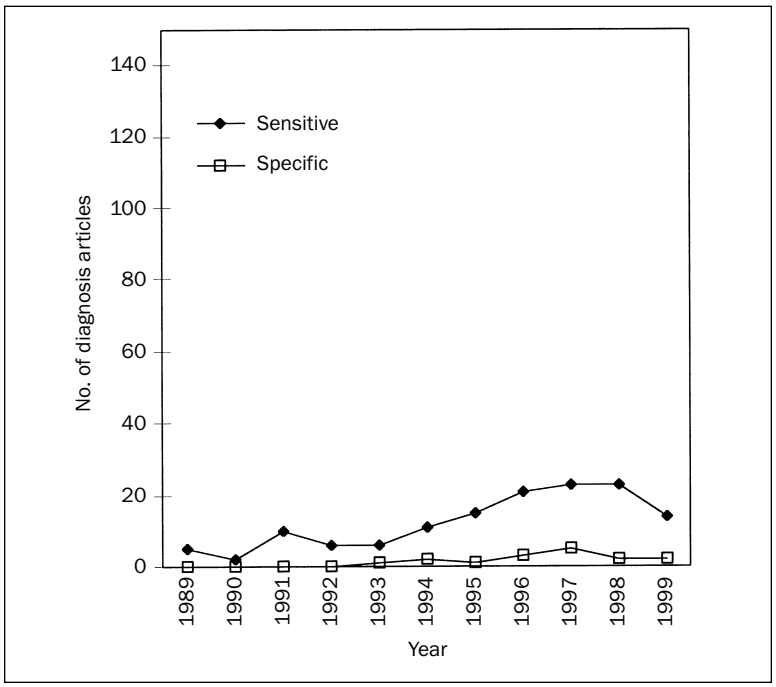

Fig 2 Time course of diagnosis publications. The time course indicates that *(1)* for all years, the sensitive search identified more articles than the specific search; and *(2)* the number of published diagnostic articles identified by both the sensitive and specific search strategies increased from 1989 to 1999.

11-year period. The mean number of articles published per year in all 4 categories combined ranged from 15 (± 11) for specific searches to 107 (± 50) for sensitive searches. The difference between a sensitive search (a strategy that retrieves the largest number of relevant articles but also includes some irrelevant ones) and a specific search (a strategy that identifies a small number of the most relevant articles but also excludes some relevant articles and most irrelevant articles) was also examined. For individual categories, the number of articles per year for specific and sensitive searches, respectively, ranged between 1.9 ± 2.5 and 58 ± 33 for etiology, between 1.5 ± 1.6 and 12 ± 7.5 for diagnosis, between 0.3 ± 0.5 and 23 ± 15 for therapy, and between 12 ± 8.3 and 67 ± 33 for prognosis. Within each category, the sensitive searches identified more articles per year than the specific searches (all $P > .001$; paired t test). Comparison of the 2 means indicates that, as expected, a sensitive search consistently identified more articles than a specific search ($P < .001$; paired t test).

The relative emphasis placed on different aspects of clinical information in implant literature is revealed by comparing publication quantity. The data depicted in Fig 1 and Table 3 were further examined to determine the relative publication quantity in each of the 4 clinical categories. For sensitive searching, the data suggest publication quantity in the decreasing order of prognosis, etiology, therapy, and diagnosis. Statistical analysis showed that the prognosis category was significantly larger than both etiology and diagnosis ($P < .001$ and $P > .05$, respectively), and etiology was significantly greater than diagnosis ($P < .001$). No other significant relationships were noted in the sensitive search.

For specific searching, the data suggest a decreasing order of search results: prognosis, etiology, diagnosis, and therapy. Statistical analysis showed that prognosis was significantly greater than diagnosis, etiology, and therapy ($P < .01$). Overall, there were significantly more articles on prognosis than on diagnosis and therapy, while etiology had significantly more articles than diagnosis.

To better understand the dynamics of information evolution in the 4 clinical categories, the searches were stratified by publication year. Figs 2 to 5 illustrate the time course of diagnosis, therapy, etiology, and prognosis publications. The figures confirm the consistency with which sensitive searches identified more articles than specific searches. The figures also suggest that for all clinical categories, the number of articles generally increased each year for sensitive and specific searches. Linear regression substantiates this impression, because the slopes were all positive in sensitive and specific searches, respectively: 1.9 and 0.4 for diagnosis, 8.9 and 0.6 for etiology, and 3.8 and 0.03 for therapy, and 9.1 and 2.1 for prognosis. These slopes were all significantly different from zero for all categories in both sensitive and specific searches (all $P < .008$; linear regression), except for therapy/specific ($P < .56$; linear regression).

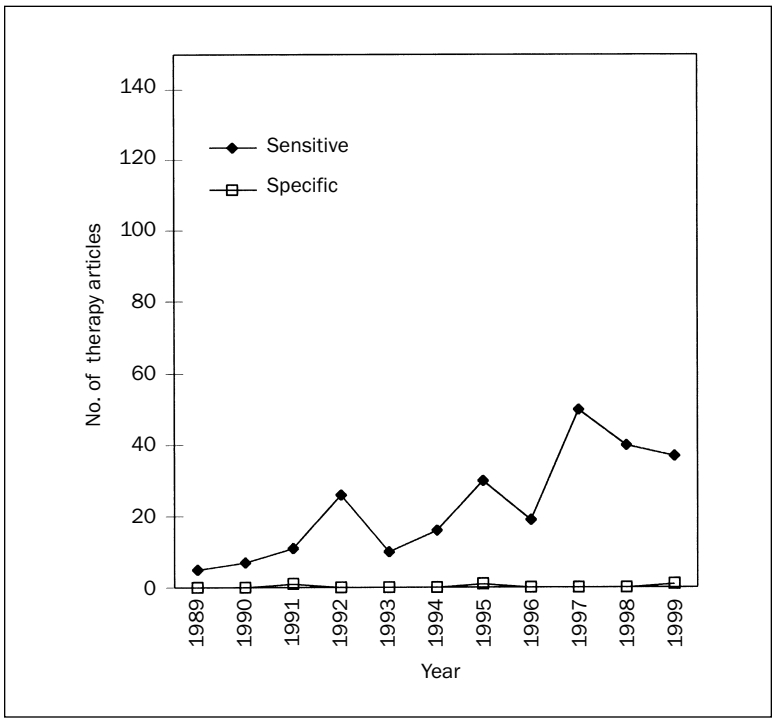

Fig 3 Time course of therapy publications. The time course indicates that *(1)* for all years, the sensitive search identified more articles than the specific search; and *(2)* the number of published diagnostic articles identified by the sensitive search strategy increased, while the specific search strategy remained relatively constant from 1989 to 1999.

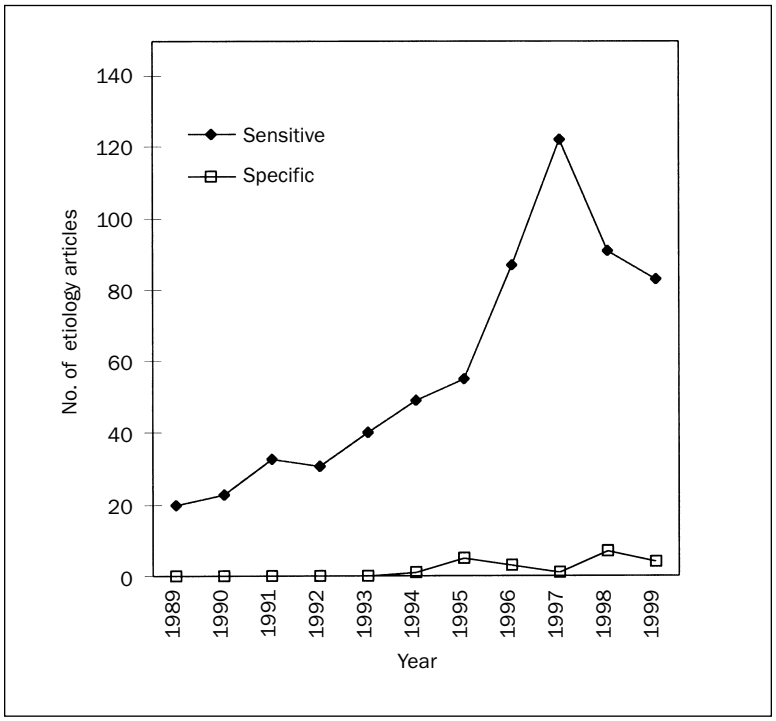

Fig 4 Time course of etiology publications. The time course indicates that *(1)* for all years, the sensitive search identified more articles than the specific search; and *(2)* the number of published diagnostic articles identified by both the sensitive and specific search strategies increased from 1990 to 1998.

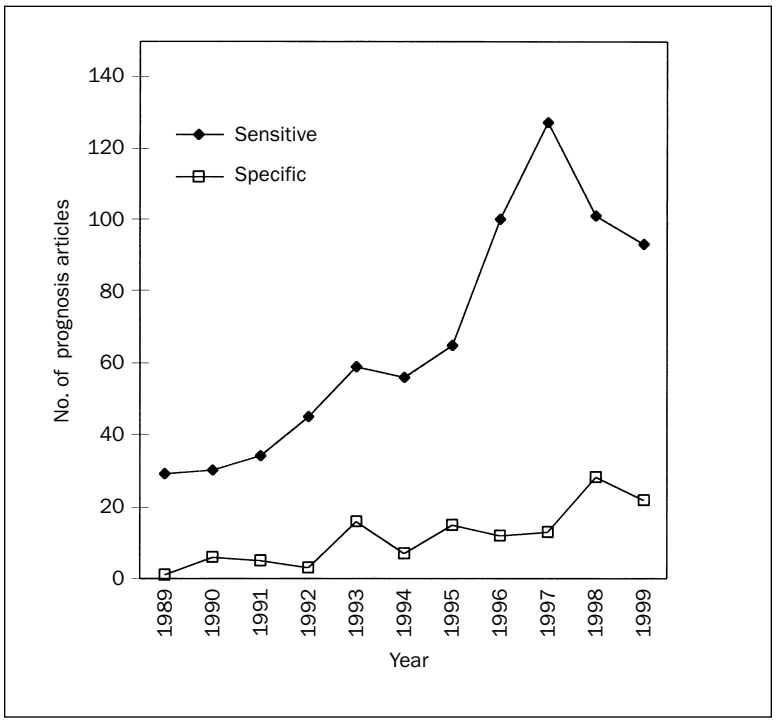

Fig 5 Time course of prognosis publications. The time course indicates that *(1)* for all years, the sensitive search identified more articles than the specific search; and *(2)* the number of published diagnostic articles identified by both the sensitive and specific search strategies increased from 1990 to 1998.

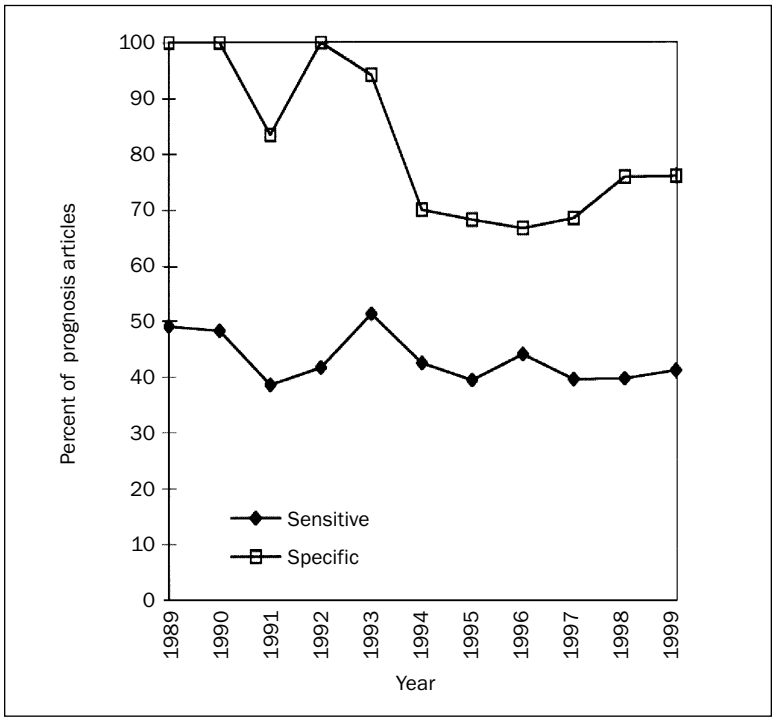

Fig 6 Time course of prognosis publications with respect to all publications combined. The time course indicates that the percent of published prognosis articles remained steady for the sensitive search strategy and decreased for the specific search strategy from 1990 to 1998.

From the above results, calculations were made to determine the average percent increase in articles over the 11-year period. The positive slopes from linear regression indicated the average increase in number of articles per year for a given category and search type (for example, diagnosis/sensitive). The corresponding mean number of articles per year was already known (Table 3); the ratio of a slope to its corresponding mean value equals the average percent increase. The average percent increases by category for the sensitive search were 42% for diagnosis, 43% for etiology, 18% for therapy, and 14% for prognosis. The average percent increases were not calculated for the specific search because of the small number of citations per category, which resulted in a poor statistical outcome. The composite average percent increase of articles per year (sum of slopes divided by sum of percent increase) is 29% for the sensitive search.

From a clinical viewpoint, the ultimate goal of clinical activities is to improve the prognosis of a patient's condition(s). In a body of balanced implant literature, publications on prognosis would constitute approximately one fourth of all publications or might even increase over time as the evidence base of other clinical information grew to support more research on prognoses. To test this hypothesis, the ratio of the number of prognosis articles to the total number of articles for all 4 categories over the 11-year period was determined. The mean percentage of prognosis articles ranged from 63% (± 5.2%) for sensitive search to 85% (± 14%) for specific search. Figure 6 illustrates that the number of prognosis articles relative to those of other categories has remained steady for the sensitive search. The specific search shows 3 trends: a steady beginning, a subsequent decrease, and a recent increase.

To examine the sources of information in the 4 clinical categories, journals that published the articles were identified. Table 4 shows the journals that yielded the greatest mean number of articles per year in all 4 categories combined over the past 6 years in the respective sensitive and specific searches: *International Journal of Oral & Maxillofacial Implants* (29 ± 12 and 7.3 ± 6.3), *Clinical Oral Implants Research* (13 ± 4.0 and 1.1 ± 1.2), *Journal of Prosthetic Dentistry* (10 ± 3.8 and 1.5 ± 0.5), and *Journal of Oral & Maxillofacial Surgery* (7.7 ± 5.5 and 1.7 ± 1.2). These 4 journals together published a mean of 60 (± 11) and 12 (± 4.0) articles per year in sensitive and specific searches, respectively, which corresponds to 42% (± 7.7%) and 53% (± 18%) of the mean total number of articles per year; approximately 97 other dental journals published the remainder of the articles.

DISCUSSION

The purpose of the current study was twofold. The first was to estimate the quantity of dental implant literature available for evidence-based clinical decision-making. The second was to identify the location of this literature. The results indicated that over the last 11 years there appeared to be a significant body of clinically relevant literature focusing on dental implants, and this literature appeared in over 80 different journals.

The implied results are, perhaps, more interesting than the actual results. First, there were on average between 15 (specific search) and 107 (sensitive search) articles published per year addressing the etiology, diagnosis, prognosis, and therapy of implants. If all of these publications are of high clinical applicability, these results suggest that one would need to read, digest, and implement into clinical practice between 1 and 2 articles per week, 52 weeks per year, to keep current. Second, all 4 categories of clinical information generally increased over the 11-year period. For example, the average increase of articles per year is 29% for the sensitive search. Given this trend, one can expect the volume of literature to increase continually in the near future. Third, while libraries (personal or public) may subscribe to the "top 4" journals and cover approximately 50% of the clinical information, it is sobering to note that this misses the other half of the literature. Thus, the challenge of keeping abreast of the literature is one of both volume and location. Fourth, there was a large emphasis on prognostic articles relative to etiology, diagnosis, and therapy. This suggests an unbalanced body of dental implant literature. Fifth, the evolution of an increasingly unbalanced body of literature suggests the need for additional etiologic, diagnostic, and therapeutic studies, and potentially the need for additional American Dental Association codes for each category and treatment. Equally conceivable will be the parallel development of a combined literature that will enhance prognostics and a more advanced understanding of case selection and the etiology of success and failure.

It should be noted that this study has a number of limitations. First, the specific and sensitive search strategies were employed to estimate, respectively, the probable lower and upper limits of the available dental implant literature. Thus, the specific search strategies may omit certain relevant articles, while the sensitive search strategies may include irrelevant articles. As expected, a specific search retrieved fewer articles than a sensitive search in all 4 categories. Second, both searches may underestimate

Table 4 Name and No. of Citation Sources (1994 to 1999)

Name of source	No. of articles per year*	SD†	% of journal‡	% of total§
Sensitive search				
International Journal of Oral & Maxillofacial Implants	29.3	12.3	35.9	20.6
Clinical Oral Implants Research	12.7	4.0	28.9	8.9
Journal of Prosthetic Dentistry	10.0	3.8	4.3	7.0
Journal of Oral & Maxillofacial Surgery	7.7	5.5	2.8	5.4
International Journal of Prosthodontics	5.7	4.5	8.4	4.0
Journal of Periodontology	5.5	3.7	3.1	3.9
Implant Dentistry	5.0	2.4	16.3	3.5
Journal of Oral Implantology	5.0	1.3	18.6	3.5
International Journal of Periodontics & Restorative Dentistry	4.8	2.1	10.8	3.4
Practical Periodontics & Aesthetic Dentistry	4.3	3.0	6.3	3.0
Compendium	2.8	1.9	3.1	2.0
International Journal of Oral & Maxillofacial Surgery	2.8	2.6	1.2	2.0
Journal of Oral Rehabilitation	2.5	1.9	2.0	1.8
Specific search				
International Journal of Oral & Maxillofacial Implants	7.3	6.3	9.0	33.6
Journal of Oral & Maxillofacial Surgery	1.7	1.2	0.6	7.6
Journal of Prosthetic Dentistry	1.5	0.5	0.6	6.9
Clinical Oral Implants Research	1.1	1.2	2.7	5.3
Implant Dentistry	0.8	0.8	2.7	3.8
Journal of Oral Implantology	0.8	0.8	3.1	3.8
Journal of Periodontology	0.8	1.2	0.5	3.8
International Journal of Oral & Maxillofacial Surgery	0.7	1.2	0.3	3.1
International Journal of Periodontics & Restorative Dentistry	0.7	0.8	1.5	3.1
International Journal of Prosthodontics	0.7	0.8	1.0	3.1
Journal of Oral Rehabilitation	0.5	0.5	0.4	2.3

*Mean no. of relevant citations per year.
†Standard deviation of total no. of citations by year (1994–1999).
‡No. of citations displayed as percent of all articles from the aforementioned journal.
§No. of citations displayed as percent of entire subset (sensitive n = 854, specific n = 131).

the actual literature. This is because the key words used in the MEDLINE search were limited to MeSH vocabulary. MEDLINE, being a bibliographic database, is normally behind the profession in adopting new language. Therefore, the searches, in not being entirely language-inclusive, may have excluded relevant articles. Third, and conversely, the searches may also overestimate the actual clinically useful literature. This is because the strategies made no attempt to evaluate the quality of the published articles. For example, the U.S. Agency for Health Care Policy and the Centre for Evidence-based Medicine (http://cebm.jr2.ox.ac.uk/docs/levels.html) categorize evidence by quality levels.[16] These groups base quality on the validity, clinical impact, and clinical applicability at a high level of evidence (eg, a randomized controlled trial is a higher level of evidence than a case series). Further assessments are needed to critically appraise the identified articles.

The current results and technology also offer some comfort to clinicians. MEDLINE is the world's largest free-access bibliographic database. PubMed, one of its access portals (http://www.ncbi.nlm.gov/pubmed/), provides a number of features to assist the clinician in identifying relevant clinical articles, saving the searches, and obtaining these articles. For example, in running searches, MEDLINE will maintain a search history and collect selected citations on a clipboard. Identified articles can then be ordered directly from MEDLINE using their Loansome Doc service (http://tendon.nlm.nih.gov/ld/loansomedoc.html). Finally, PubMed can save searches, and the clinician can rerun this search at daily, weekly, monthly, or yearly intervals without having to recreate the search strategy.

CONCLUSION

The search strategies, methodologic filters, and results demonstrate a substantial and increasing dental implant literature. The results also provide a pathway for clinicians to carry out their own bibliometric assessments and information retrieval, beyond the limits of current journal subscriptions. However, the responsibility for critical appraisal and clinical application of the identified information still resides with the clinician. The results also provide a pathway for academics concerned about the evidence base for curricular decisions, researchers interested in identifying gaps in the available knowledge base, corporate entities interested in developing new products, policy makers who fund clinical research, health care purchasers who make decisions about care compensation, and finally, professional societies that seek to provide guidance for their membership.

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