STUDY DESIGN STRENGTH OF EVIDENCE AND LEVEL OF CLINICAL EFFICACY REPORTED IN THE CBCT SCIENTIFIC LITERATURE

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ABSTRACT

Robert J. Timothy: Study Design Strength of Evidence and Level of Clinical Efficacy Reported in the CBCT Scientific Literature
(Under the direction of Andre Mol)

Objective: To determine strength of evidence and level of efficacy for cone-beam computed tomography (CBCT) in dentistry. Scientific articles assessed by epidemiologic study design and level of efficacy. The following null-hypotheses were tested: 1: No temporal changes in study design and efficacy of CBCT literature from inception until June 2013. 2: No differences in study design and efficacy of scientific articles between clinical disciplines. 3: No differences in study design and efficacy between journals. 4. No differences in study design and efficacy between countries.

Methods: A PubMed search of English scientific dental literature regarding CBCT was conducted. Two evaluators independently assessed the selected articles.

Results: The number of articles published increased almost exponentially. An increase in efficacy over the time of this study was significant (P=0.04).

Conclusions: Study design evidence has not changed temporally; however, efficacy level shows a significant increase over time.

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LIST OF ABBREVIATIONS AND SYMBOLS

2D	Two-Dimensional
3D	Three-Dimensional
ADA	The American Dental Association
CBCT	Cone-beam Computed Tomography
CBVT	Cone-beam Volumetric Tomography
CT	Computed Tomography
DMFR	Dentomaxillofacial Radiology
Euratom	European Atomic Energy Community
N/A	Not Applicable
OMFR	Oral Maxillofacial Radiology
OMR	Oral and Maxillofacial Radiology
OMS	Oral Maxillofacial Surgery
OOOOE	Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontics
PDF	Portable Document Format
RCT	Randomized Clinical Trials
UK	United Kingdom
USA	United States of America

INTRODUCTION

Dentists are continually making clinical decisions that affect the health of their patients, including diagnostic decisions and treatment decisions. While the scientific basis for current practice has dramatically expanded in the past decades, clinical decisions are not always based on best available evidence. Instead, the influence of information based on unverified and potentially biased sources, including expert opinion, non-refereed journals and product literature, remains ubiquitous. A gradual shift has taken place over the past two decades to incorporate best available evidence in the practice of medicine and dentistry. The term evidence–based medicine first appeared in a publication in the early 1990's and is now widely used in many different health related fields, including dentistry[1]. The American Dental Association (ADA) developed the following definition for the term evidence-based dentistry: "an approach to oral health care that requires the judicious integration of systematic assessments of clinically relevant scientific evidence, relating to the patient's oral and medical condition and history, with the dentist's clinical expertise and the patient's treatment needs and preferences"[2]. A series of articles published in The Journal of the American Dental Association (A practitioner's guide to developing critical appraisal skills) had the stated purpose of helping the practitioners to incorporate research and evidence based dentistry by developing the skills and understanding

necessary to make an appraisal of the scientific literature[3-8]. This series was followed up more recently with another series of articles entitled "A practical approach to evidence-based dentistry" introducing evidence based dentistry and explaining how to appraise the evidence and use it in clinical decisions[9-12].

While the practice of evidence-based dentistry appears commonsense, its adoption has not been without dispute. The lack of sound scientific studies and the limited generalizability of studies to specific patient scenarios are often quoted as barriers in the implementation of evidence-based practice[13]. The term evidence-based is sometimes misinterpreted to mean that clinical practice cannot be sustained in the absence of sound scientific proof. While scientific literature is important for healthcare providers in their quest to provide evidence-based treatment, knowledge and use of scientific literature does not imply that the scientific evidence is strong. Emerging fields may require time to collect sound scientific data and other areas may require vast resources to accomplish this task. The quality of the scientific evidence has the potential to greatly impact patient outcomes, both on an individual patient level as well as on a societal level. It is for this reason that the ADA in its definition emphasized the need for systematic assessment of clinically relevant scientific evidence that is the basis for oral health care. This definition has two important implications: (1) the clinician needs to be familiar with the scientific literature and be able to understand and interpret its content; and (2) clinically relevant scientific evidence may not be present or may be weak. The former requires dentists to be trained in scientific principles and methodology and the latter may point to areas in clinical practice that require further scientific investigation. The need for a scientific basis becomes particularly important when the benefits of a procedure come at a potentially significant cost. Costs represent the

collective undesirable components associated with a procedure, including but not limited to monetary costs, morbidity and mortality.

In radiology, a decision to perform a diagnostic imaging procedure requires that the expected benefits of the images outweigh their costs. While the financial burden of advanced imaging procedures should not be underestimated, most attention on the costs of radiological procedures is focused on the risks associated with exposure to ionizing radiation. To this end the European Atomic Energy Community (Euratom) published evidence-based guidelines for cone beam CT for Dental and Maxillofacial Radiology[14]. These risks can be calculated fairly precisely and can be compared to other types of risks experienced on a day-to-day basis.

The benefits of an imaging procedure often appear self-evident; however, limitations in sensitivity and specificity, the potential impact of the imaging procedure on different levels of outcome and the values associated with correct or incorrect test results represent a formidable challenge for the clinician. The decision-making process is further complicated by the rapid advancements in imaging technology, requiring an almost constant reassessment of variables in the cost-benefit equation. The scientific evaluation of emerging technologies plays a very important role in providing unbiased information that is essential for making decisions that maximize the chance of a desirable outcome. As the strength of evidence and clinical significance of this information is determined by the scientific study design, it is of interest to assess what types of studies are published in the literature, both in terms of the strength of evidence of their study design and their level of clinical efficacy.

Different research designs provide different levels of evidence and therefore, different levels of value in evidence based-dentistry. The traditional study designs fall in either one of two categories: observational or experimental [15]. Observational study designs form a hierarchy

from weak to strong and include: case reports, case series, cross-sectional, case control, and cohort studies (Table 1).

Case reports and case series consist of one or more cases with a detailed description of the clinical presentation and can include histopathology, pathophysiology, differential diagnosis and other clinically relevant information. Cross-sectional studies examine the relationship between disease and other variables at the same point in time for a defined group of subjects. It measures current disease prevalence against current exposure prevalence. Case-control studies examine relationships between exposure and disease based on exposure history; subjects are defined as cases (those having the disease) and as controls (those not having the disease). In cohort studies, subjects are classified on the basis of exposure and followed through time to examine if a disease develops or not. At least two observational points are chosen. The strongest evidence is provided by experimental study designs, such as the randomized clinical trial. Randomized clinical trials (RCT) compare two groups that are randomly assigned to either the experimental or the control group. The RCT is considered the gold standard for evidence-based dentistry and clinicians should look for clinical research with the highest level of evidence available for clinical decision making.

In addition to classifying studies based on their design, studies can also be classified according to their potential impact on patient outcomes. Impact and outcomes are related to medical decision making which as a field has grown substantially [16]. Fryback and Thornbury describe the evolution of the efficacy model that parallels medical decision making and elaborated on the traditional medical decision making model with a diagnostic imaging model based on efficacy[17]. They introduced a hierarchical model of efficacy consisting of six levels (Table 2). The lowest level is the technical efficacy of an imaging modality, which is assessed

by physical parameters describing various aspects of the modality, such as contrast, modulation transfer function, dose and artifacts. The second level is the diagnostic accuracy efficacy, which represents how accurately the outcome of the test reflects the true disease state of the patient. Measures of diagnostic accuracy include sensitivity and specificity, predictive values and area under the receiver operating characteristic curve (ROC). The third level is the diagnostic thinking efficacy. This represents the extent to which an image is judged helpful in making a diagnosis as measured by, for instance, the impact on the differential diagnosis probability distribution or the difference in pre- and post-test probabilities. The fourth level is the therapeutic efficacy. This represents the degree to which an image is helpful in planning patient management as measured by the retrospective or prospective alteration of a treatment plan after the image information is obtained. The fifth level is the patient outcome efficacy, which is a measure of the effect of the test on patient-related outcomes, such as morbidity, changes in life expectancy, cost, function and esthetics. The sixth and highest level is the societal efficacy. At this level, the impact of the imaging modality on society is assessed using cost-benefit analyses. In order for a diagnostic imaging modality to be efficacious at a higher level, it must be efficacious at the levels below. However, high efficacy at a lower level does not automatically imply high efficacy at a higher level.

It is expected that early scientific studies of new technology focus on the first two levels of efficacy, i.e. technical efficacy and diagnostic efficacy. When such studies show positive outcomes that justify the use of these technologies for clinical applications, the need for further studies addressing higher levels of efficacy are needed. This is particularly true for technologies that have a substantial impact on costs, risks and potential benefits. This provides a deeper understanding of the impact of new technology on treatment decisions and outcomes.

The impact of a new technology that shows improved technical and diagnostic abilities, but fails to alter treatment decisions and outcomes is low. The need for studies addressing higher levels of efficacy according to the Fryback and Thornbury model is thus self-evident. However, it is recognized that such studies represent a significant challenge compared to those addressing lower levels of efficacy. The assessment of the higher levels of efficacy for a new technology is increasingly complicated by the influence of other factors. Isolating the effect of the imaging modality on treatment decisions and outcomes is a difficult task, requiring careful study designs.

The potential need for assumptions and simplifications may reduce the generalizability of the results and thus the relevance of the study to clinical practice. Nevertheless, a lack of strong evidence for efficacy at higher levels is problematic and could lead to wrongful acceptance of an imaging modality. The normal progression of research would suggest that early studies focus on safety and accuracy and subsequent studies include clinical trials that answer questions of clinical importance at a higher efficacy level.

This is particularly important for emerging advanced imaging modalities that provide potentially high benefits but also carry a higher cost. In recent years, the development and use of advanced three-dimensional (3D) imaging modalities in medicine and dentistry has dramatically increased. Computed tomography (CT) imaging has revolutionized many aspects of medical imaging since its introduction in the early 1970's and has been referred to as the most important invention in diagnostic radiology since the discovery of the x-ray.[18] CT use in dentistry was limited at first due to the high cost, high dose and limited access to scanners. However, cone-beam computed tomography (CBCT), which was initially developed for angiography in the early 1980's, proved to be a lower cost alternative that met the needs of the oral maxillofacial region. In the 1990's, Arai and co-workers and Mozzo and co-workers independently developed CBCT

units for the oral maxillofacial region and ushered in the CT revolution in dentistry[19, 20]. The CBCT technique is based on a cone-shaped or pyramid-shaped x-ray beam that acquires a series of 2D images as both the source and detector rotate once around the object of interest. The images are then reconstructed in 3D using complex mathematical algorithms. While CBCT is the most costly imaging modality ever developed for dentistry and imparts the highest dose to the patient compared to traditional dental x-ray modalities, it is gaining acceptance in many aspects of dentistry and is becoming the standard of care in certain clinical settings. The question is whether the acceptance of this modality is supported by scientific studies providing evidence for its use and whether the scientific literature has matured since its inception. Furthermore, are there differences in the strength and efficacy of scientific articles associated with different clinical disciplines and are they increasing over time? Areas of particular interest in this regard include implant site assessment, orthodontics, oral surgery, periodontology and endodontics. Finally, are there differences in the strength and efficacy of scientific articles published in journals with a radiology focus versus other journals or between different geographic regions?

Similar studies in medicine have been completed helping the respective health care fields better understand the existing research[21-29]. The Fletchers reviewed articles from the three most widely circulated English-language journals of the time (The Journal of the American Medical Association, The Lancet and The New England Journal of Medicine) and found that over a thirty year period from 1946 to 1976 studies with weak research designs increased and concluded that the trend deserved critical attention[30]. This study was followed up by a similar study that studied scientific articles from the same three major medical journals from 1971 to 1991[26]. The results from McDermott and co-workers showed several important changes form the study by the

Fletchers in that the randomized clinical trials and multicenter studies increased and case series and nonrandomized controlled trials decreased, indicating an increase in the clinical evidence of the literature. In Obstetrics and Gynecology 151 articles from 1991 to 2001 were classified by research methodology and level of evidence and it was noted that analytic studies increased while anecdotal reports decreased[24]. Clinical studies published in neurosurgical journals from 1982, 1992 and 2002 were similarly evaluated and notwithstanding the modest increased in randomized clinical trials, case reports remained the predominate study design[25]. A study describing nursing research from 1956 to 1983 showed a peak in the use of experimental designs in the 1960s with a decline in 1983[22]. Another study in Radiology that aimed to determine the use of advanced imaging techniques found results that suggest that criteria such as study design and relevance for daily clinical use have a major impact on the acceptance of papers in clinically oriented radiology journals[27]. A study of 1,831 articles from four otolaryngology journals over a 20-year period found that clinical research increased in both quality and quantity[28].

Previous studies pertaining to bibliographic assessment of the dental literature are scarce, but not absent. Kim and co-workers reviewed the oral and maxillofacial radiology (OMR) literature between 1996 and 2005 and classified the literature by study design and efficacy levels.[31] They found that the OMR literature consisted mostly of case reports and case series as well as cross-sectional studies at the technical and diagnostic accuracy efficacy levels. They concluded that the strength of evidence and level of clinical efficacy of the literature was low. A systematic review of the literature with respect to cone-beam computed tomography (CBCT) of the oral and maxillofacial region was published in 2009 by De Vos and co-workers[32]. They performed a search of articles published between 1998 and 2007 and categorized them by clinical specialty. They found that there was a lack of evidence-based data on the radiation dose

for CBCT imaging and that terminology and technical device properties and settings were not consistent in the literature. In an unpublished pilot study, Kim and co-workers evaluated the study design and diagnostic efficacy of the CBCT literature through 2008.[33] Their results showed that the majority of studies did not provide strong evidence for informed clinical decision making.

To our knowledge, a complete and update assessment of the CBCT literature with regard to study design and efficacy level does not exist. Such an assessment will show whether there are temporal changes in the literature and whether there are differences between clinical disciplines, journal types and between geographic regions. This study may find that the literature in general has matured and that the use of CBCT in dentistry is based on sound scientific evidence. On the other hand, this study may also find a lack of evidence, either generalized or only in certain clinical discipline areas. In this case, the proposed study can point to areas of weakness and establish a basis for future study design.

The aims of this study were to evaluate the scientific literature published in dental journals and establish whether the literature was maturing with regards to study design and efficacy levels over time. To accomplish these aims the following null-hypothesis's were tested: 1: No temporal changes in study design and efficacy level of CBCT literature from inception until present; 2: No differences in study design and efficacy level of scientific articles between clinical disciplines; 3: No differences in study design and efficacy level between radiology journals and other journals; 4: No differences in study design and efficacy level between different countries by corresponding author

METHODS AND MATERIALS

Sample

The sample for this study comprised all articles on CBCT published in the English-language dental journals indexed in PubMed (National Center for Biotechnology Information, U.S. National Library of Medicine, Bethesda, MD) from the inception of CBCT for dentistry to June 2013.

Search Strategy

In order to capture all published scientific articles on CBCT in the dental journals, the following search strategy was used: Mesh term “Cone-Beam Computed Tomography”, and the following text words; CBCT, CBVT, Cone beam computed tomography and Cone beam volumetric tomography with the English language and dental journal filters being used.

Article Classification

In order to classify the clinical research articles, a definition of clinical research as it pertains to this study was necessary. For the purposes of this study we defined clinical research as research in which the objects of study were patients (images), providers (observers), or institutions (environment). The study designs that did not fit this definition were classified as

other or not-applicable. Articles were downloaded in Portable Document Format (PDF). Each article was evaluated by two investigators. The investigators were a board certified Oral Maxillofacial Radiologist and an Oral Maxillofacial Radiology resident (primary author).

Prior to the classification of the actual sample, the investigators completed training and calibration sessions. The calibration consisted of a series of twenty articles spanning the various levels of study design and efficacy. The articles were not any of the articles that were considered in this study. The calibration samples were provided by a third investigator; a board certified Oral Maxillofacial Radiologist with more than 35 years of expertise in health care, public health, epidemiology, dentistry and academic scholarship, who did not participate in the assessment of the main study sample but acted as the trainer and calibrator for the project. Following classification of the calibration sample, the investigators discussed the results, learning from cases of agreement and disagreement. Review and classification of the actual sample were performed independently by the two investigators (one being the primary author). Ongoing calibration consisted of classification by the calibration evaluator of a random subset of articles already evaluated by both evaluators. If it was determined that the two evaluators were out of calibration, training and additional calibration modules were offered as necessary. When there was disagreement about the classification regarding either or both of the evaluation variables, the article was reviewed together and a consensus was reached. When consensus could not be reached, the third investigator independently classified the articles in question and then reviewed the results of the other investigators. The articles were then discussed and a consensus was reached. Articles that did not match a traditional study design, other category or efficacy levels were classified as not-applicable (N/A).

The following classifications were used to enter the results into an Excel (Microsoft Corp., Redmond, WA) file for study design: Case Report (1 or 2 cases), Case Series (3 or more cases), Cross-sectional, Case-control, Cohort, Experimental, and other (Table 3). For efficacy, the following classifications were used to enter the results; Technical, Diagnostic Accuracy, Diagnostic Thinking, Therapeutic, Patient Outcome, Societal and Not Applicable (Table 4).

Clinical disciplines were also used to categorize the articles by the general topic of the article related to the following disciplines; Dental public health, Endodontics, General Dentistry, Implantology, Oral and Maxillofacial Pathology, Oral and Maxillofacial Radiology, Oral and Maxillofacial surgery, Orthodontics and Dentofacial Orthopedics, Pediatric Dentistry, Periodontology, Prosthodontics and Not Applicable (Table 5).

The articles were categorized by clinical discipline using the following rules: (1) determine the general topic of the article and the discipline it best aligned with, (2) if two or more disciplines could be assigned, the article defaulted to the discipline of the journal that the article was published in (for example, orthognathic surgery could be the topic of the article explaining the surgical as well as the orthodontic procedures, because the article was published in the Journal of Oral and Maxillofacial Surgery, however, the article would be assigned to Oral and Maxillofacial Surgery), (3) if the article was published in one of the general dentistry journals and two or more disciplines could be used to classify the article, the main authors department or clinical discipline was used as long as their clinical discipline or department was one of the disciplines originally defined, (4) articles that still could not be categorized were discussed by the two evaluators and a consensus was reached. When a consensus could not be reached a third evaluator was consulted.

The articles were also coded by journal of publication. The journal codes were assigned alphabetically starting with the code of 1 for Acta Odontologica Latinoamericana: AOL and ending with the code of 116 for World Journal of Orthodontics (APPENDIX 1). The journals were then coded as "Radiology Journals" and "Other Journals", the "Radiology journals" consisting of Dentomaxillofacial Radiology (DMFR) and Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontics (OOOOE) and the "Other journal" consisting of all remaining journals.

The articles were further classified by the country of origin of the corresponding author (Table 6). 39 countries were initially identified and preliminary analysis revealed that 70% of the articles were produced by authors from seven countries. Each of the seven countries identified were then coded individually with the remaining countries (32 countries) being coded together as the "Other Countries" category.

Data Analysis

SPSS 22 (SPSS, Inc., Chicago, IL) was used for descriptive statistical analysis and for the creation of the charts and graphs related to those descriptive statistics. SAS 9.3 (SAS Institute, Cary NC) was used to perform weighted linear regression analysis to evaluate temporal changes in the two hierarchies in general and for changes in the hierarchies between clinical disciplines, between journals and between countries of origin by corresponding authors. SAS 9.3 was also used to perform pairwise ANCOVA to measure the linear associations between the different clinical disciplines, different journals and different countries of corresponding authors. The main aim of this study was to evaluate for temporal changes and weighted linear regression analysis was considered the most appropriate method to test for these differences in this study. The dependent variables were study design and efficacy level with the independent variable being

year of publication (time) and then adding in the interaction of the variables; clinical discipline, journals and country of corresponding author. Preliminary analysis returned very few articles for the years 2003 through 2006, so these years were combined into time period 1 and then each consecutive year 2007 to 2013 were assigned to time periods 2 through 7 respectively. Multiple linear regressions apply the best fit line principle and allowed for time trend comparison of both positive and negative trends. With regards to assigning the weighted values, weights were assigned in numerical order from lowest level of hierarchies to the highest level of hierarchies, increasing in increments of ones.

RESULTS

Study Design and Efficacy Level

The search resulted in1651 articles (Figure 1). 515 of these articles met the definition of CBCT research and were classified according to the traditional epidemiological study design hierarchy. Of these 515, there were 229 case reports, 69 case series, 192 cross-sectional, 4 case-control, 12 cohort and 9 experimental studies (Table 7, Figure 2). There was no statistically significant difference in study designs over the time frame of this study (Table 8) (Figure 3). Of the 492 articles that were classified by the six efficacy levels, 21 were technical, 376 were diagnostic accuracy, 73 were diagnostic thinking, 8 were therapeutic, 13 were patient outcome and 1 was societal (Table 9, Figure 4).

All six levels of the hierarchy were represented; however, 80% of the articles were of the two lowest levels of the hierarchy. The statistical significant difference in efficacy level over the time frame of this study (Table 10, $P<0.01$) (Figure 5) indicated a positive trend towards articles with higher efficacy levels. However, with the majority of the articles at the lower efficacy levels the effects on clinical decisions or health care policies may not be significant.

Clinical Disciplines

Of the 10 clinical disciplines that were identified, all of the articles were classified into one of the disciplines with the exception of 99 articles which were classified as not applicable (N/A). Examples of articles that were not applicable were articles that were editorials, letters to the editor and viewpoints. The distribution of the articles by clinical discipline was; 491 Oral and Maxillofacial Radiology, 316 Orthodontics and Dentofacial Orthopedics, 214 Oral and Maxillofacial Surgery,186 Endodontics, 179 Implantology/ Implant Dentistry, 56 General Dentistry, 21 Pediatrics, 11 Prosthodontics and 4 Oral and Maxillofacial Pathology (APPENDIX 2, Figure 6).

The distribution of articles by clinical discipline and by study design was cross-tabulated and graphed by percentage and can be found in Table 11 and Figure 7 respectively. There was a statistically significant difference between clinical disciplines by study design ($P<0.01$, Table 12,) and the regression lines demonstrate a positive trend for all clinical disciplines except Oral Maxillofacial Pathology and Periodontology which show negative trends in study design over the study period (Figure 8). The differences between clinical discipline, study design and year of publication, however, were not significant ($P=0.76$, Table 12,). Post hoc pairwise ANCOVA comparisons using the least square means analysis, with study design as the dependent variable, resulted in a significant difference between the following clinical disciplines; Endodontics and Pedodontics ($P=0.08$), General dentistry and Implantology ($P=0.04$), General Dentistry and Pathology ($P =0.01$), General Dentistry and OMR, ($P <0.01$), General Dentistry and Periodontology ($P <0.01$), Pathology and Pedodontics ($P =0.01$), OMR and Pedodontics ($P <0.01$), Orthodontics and Pedodontics ($P =0.01$) and Periodontology and Pedodontics ($P <0.01$) (Table 13).

Within the clinical disciplines the articles were also classified by efficacy levels. The distribution of the articles by efficacy level is shown by count in Table 14 and by percentage in Figure 9. The distribution of the articles by clinical discipline and year of publication can be found in APPENDIX 3. There was a significant difference between clinical disciplines by efficacy level ($P<0.01$, Table 15) and the regression lines demonstrated a positive trend for all clinical disciplines except Implantology which shows a negative trend (Figure 10). The differences between clinical disciplines by efficacy level and by year of publication over the time frame of this study, however, were not significant ($P=0.54$, Table 15,). The post hoc pairwise ANCOVA comparisons using the least square means analysis for clinical discipline with efficacy level as the dependent variable showed significant differences (Table 16) between the following clinical disciplines; Endodontics and OMS ($P<0.01$), Implantology and OMR ($P<0.01$), Implantology and Orthodontics ($P=0.01$), OMR and OMS ($P<0.01$) and OMS and Orthodontics ($P<0.01$).

Journal of Publication

Articles classified by journal of publication resulted in 271 articles classified as Radiology Journals and 1380 articles classified as Other Journals. The distribution of articles in Radiology Journals by study design resulted in 23 case reports, 11 case series, 40 cross-sectional, 2 case-control, 2 cohorts and 3 experimental. The distribution of articles in Other Journals by study design resulted in 206 case reports, 58 case series, 152 cross-sectional, 2 case control, 10 cohort and 6 experimental. (Table 17, Figure 11) There was a statistically significant difference in study design between Radiology Journals and the Other Journals category ($P<0.001$, Table 18) with Radiology Journals having a higher average mean study design, however, there was not any

significant differences when the variable for year of publication was added to the analysis(P=0.29) (Table 18).

The distribution of articles in Radiology Journals by efficacy level resulted 9 technical, 103 diagnostic accuracy, 12 diagnostic thinking, 2 therapeutic, 1 patient outcome and 0 societal. The distribution of articles in Other Journals by efficacy level resulted 12 technical, 273 diagnostic accuracy, 61 diagnostic thinking, 6 therapeutic, 12 patient outcome and 1 societal (Table 19). There was a statistically significant difference between the Radiology Journals and the Other Journals category by efficacy level (P=0.04, Table 20, Figure 12) with the Other Journals having a higher average mean for efficacy levels. When the variable year of publication was added to the weighted linear regression model, however there were not any significant differences over time (P=0.21, Table 20).

Country of Corresponding Author

Articles classified by country of corresponding author resulted in 39 countries being identified. Preliminary analysis showed that seven countries accounted for 70% of the articles that were published in the dental journals (APPENDIX 4, APPENDIX 5). The seven countries with the highest numbers of articles were the United States of America with 531 articles, Brazil with 163 articles, Germany with 121 articles, The United Kingdom with 97 articles, Japan with 93 articles, Turkey with 77 articles, and South Korea with 74 articles. The remaining 32 countries accounted for 495 articles combined. The results for the distribution of articles by each of the top seven countries individually and the other countries as a single group by study design and by efficacy level as well as corresponding percentages within these groups are listed in Table 21and Table 22 and in Figure 14 and Figure 15.

There was a statistically significant difference in study designs between countries by corresponding author (P=0.01, Table 23) with Brazil having the highest overall average mean for study design. The fixed plot of means for country of corresponding author with study design as the dependent variable showed positive trends over time toward higher study designs for all countries except Brazil which showed a negative trend toward lower study designs (Figure 16). When the variable for publication year was added to the weighted linear regression model, however, there were no significant differences for study design over the time frame of this study (P=0.66, Table 23). Post hoc pairwise ANCOVA comparisons using the least square means analysis for country by corresponding author with study design as the dependent variable showed that the significant differences were between the following countries; Brazil and Germany (P=0.02), Brazil and Japan (P=0.02), Brazil and Turkey (P=0.01), USA and Germany (P=0.01), USA and Japan (P=0.01) and USA and Turkey (P<0.01) (Table 24).

With regards to country by corresponding author, where efficacy was the dependent variable in the weighted linear regression analysis, there was not a statistically significant difference in efficacy level between countries(P=0.24, Table 25) and no significant difference in efficacy level over the time frame of this study (P=0.49). The fixed plot of means for country of corresponding author with efficacy as the dependent variable showed positive trends over time toward higher efficacy levels for all countries except South Korea which showed a negative trend over time toward lower efficacy levels (Figure 17).

Tables

Table 1 Traditional Study Designs

Study Design	Description
Case report	The presentation of one or two new cases
Case series	The presentation of three or more new cases
Cross-sectional	Examines relationships between exposure and disease prevalence in a defined population at one point in time
Case-control	Examines relationships between exposure and disease based on exposure history ; subjects are defined as cases (those having the disease) and as controls (those not having the disease)
Cohort	Subjects are classified on the basis of exposure and followed through time to examine if a disease develops or not. At least two observational points are chosen
Experimental	Preventive or clinical trials with non-random or random allocation

Table 2 Hierarchical Model of Efficacy According to Fryback and Thornbury

Level	Description
Technical efficacy	Technical quality of an imaging modality as assessment by physical parameters describing various aspects of an imaging modality, such as contrast, modulation transfer function, dose and artifacts.
Diagnostic accuracy efficacy	Yield of normal or abnormal diagnoses in a group of cases as assessed with sensitivity and specificity, predictive values or ROC analysis*
Diagnostic thinking efficacy	The extent to which an image is judged helpful in making a diagnosis as measured by, for instance, the impact on differential diagnosis probability distribution or difference in pre- and post-test probabilities
Therapeutic efficacy	The degree to which an image is helpful in planning patient management as measured by the retrospective or prospective alteration of a treatment plan after the image information is obtained
Patient outcome efficacy	The proportion of patients who improve with the test compared to those without the test as measured by outcome measures such as morbidity, changes in life expectancy, cost, function and esthetics.
Societal efficacy	The impact on society as determined by a cost-benefit analysis

*ROC: Receiver Operating Characteristic

Table 3 Study Design Codes

Study Design	Code	Study Design	Code
Case Report (1 or 2 cases)	2	Cohort	6
Case series (3 or more cases)	3	Experimental	7
Cross-sectional	4	Other	8
Case-control	5		

Table 4 Efficacy Level Codes

Efficacy Level	Code	Efficacy Level	Code
Technical	1	Patient Outcome	5
Diagnostic Accuracy	2	Societal	6
Diagnostic Thinking	3	Not Applicable (N/A)	9
Therapeutic	4		

Table 5 Clinical Discipline Codes

Clinical Discipline	Code	Clinical Discipline	Code
Dental Public Health	1	Oral and Maxillofacial Surgery	7
Endodontics	2	Orthodontics and Dentofacial Orthopedics	8
General Dentistry	3	Pediatric Dentistry	9
Implantology/ Implant Dentistry	4	Periodontology	10
Oral and Maxillofacial Pathology	5	Prosthodontics	11
Oral and Maxillofacial Radiology	6	N/A, letters to the editors etc.	12

Table 6 Country of Corresponding Author Codes

Country of corresponding author	Code	Country of corresponding author	Code
Argentina	1	Latvia	21
Australia	2	Lebanon	22
Austria	3	Netherlands	23
Belgium	4	New Zealand	24
Brazil	5	Romania	25
Canada	6	Saudi Arabia	26
Chile	7	Serbia	27
China	8	Singapore	28
Denmark	9	South Korea	29
Egypt	10	Spain	30
Finland	11	Switzerland	31
France	12	Sweden	32
Germany	13	Taiwan	33
Greece	14	Thailand	34
Hungary	15	Turkey	35
India	16	United Kingdom	36
Iran	17	United States of America	37
Israel	18	South Africa	38
Italy	19	Mexico	39
Japan	20		

Table 7 Number of Articles by Study Design by Year

		Study Design							
		Case Report	Case Series	Cross-sectional	Case-Control	Cohort	Experimental	Other	Total
Year of publication	2003	0	0	0	0	0	0	6	6
	2004	1	2	0	0	0	0	3	6
	2005	0	2	0	0	1	0	6	9
	2006	1	2	0	0	0	0	17	20
	2007	7	6	6	0	0	1	41	61
	2008	20	4	12	0	0	0	78	114
	2009	32	6	22	0	4	0	138	202
	2010	37	8	29	0	0	1	170	245
	2011	47	15	43	1	2	1	220	329
	2012	58	21	54	1	3	3	282	422
	2013	26	3	26	2	2	3	175	237
Total		229	69	192	4	12	9	1136	1651

Weighted linear regression analysis P=0.34

Table 8 Weighted Linear Regression Analysis for Study Design

Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	Intercept	1	2.94	0.11	26.60	<.01
Pub_Year	Pub_Year	1	0.03	0.03	1.04	0.34

Table 9 Number of Articles by Efficacy Level by Year

		Efficacy Level							
		Technical	Diagnostic Accuracy	Diagnostic Thinking	Therapeutic	Patient Outcome	Societal	N/A	Total
Year of publication	2003	0	1	0	0	0	0	5	6
	2004	1	1	0	0	0	0	4	6
	2005	1	2	1	0	0	0	5	9
	2006	0	7	0	0	0	0	13	20
	2007	1	19	2	0	0	0	39	61
	2008	2	26	4	0	0	0	82	114
	2009	0	48	8	1	3	0	142	202
	2010	3	62	8	1	0	0	171	245
	2011	2	62	22	1	1	0	241	329
	2012	7	92	22	0	3	1	297	422
	2013	4	56	6	5	6	0	160	237
Total		21	376	73	8	13	1	1159	1651

Weighted linear regression analysis P<0.01

Table 10 Weighted Linear Regression Analysis for Efficacy Levels

Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	Intercept	1	1.97	0.04	44.45	<0.01
Pub_Year	Pub_Year	1	0.05	0.01	3.89	<0.01

Table 11 Number of Articles by Clinical Discipline and Study Design

	Study Design							
Clinical Discipline	Case Report	Case Series	Cross-sectional	Case-Control	Cohort	Experi-mental	Other	Total
Dental Public Health	0	0	0	0	0	0	3	3
Endodontics	45	15	16	0	5	0	105	186
General Dentistry	11	0	2	0	0	0	43	56
Implantology/ Implant Dentistry	23	9	19	0	0	1	127	179
Oral and Maxillofacial Pathology	17	2	4	0	0	0	4	27
Oral and Maxillofacial Radiology	34	17	82	3	1	2	352	491
Oral and Maxillofacial Surgery	45	19	15	1	6	3	125	214
Orthodontics and Dentofacial Orthopedics	29	4	43	0	0	3	237	316
Pediatric Dentistry	12	0	0	0	0	0	9	21
Periodontics	3	2	8	0	0	0	35	48
Prosthodontics	3	0	0	0	0	0	8	11
N/A	7	1	3	0	0	0	88	99
Total	229	69	192	4	12	9	1136	1651

Weighted Linear regression analysis for clinical discipline by study design P=0.01

Table 12 Weighted Linear Regression Analysis for Clinical Discipline by Study Design

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Pub_Year	1	5.35	5.35	5.66	0.02
Clinical_Discipline_Code	7	47.07	5.88	6.23	<0.01
Pub_Year*Clinical_Discipline_Code	6	3.35	0.42	0.44	0.89

Table 13 ANCOVA Pairwise Least Square Means Analysis by Study Design and Clinical Discipline

Specialty_Code	Study_Design_Mean LSMEAN
Endodontics	2.77
General Dentistry	2.02
Implantology	2.98
Pathology	2.74
OMS	3.43
OMR	2.73
Orthodontics	3.29
Pedodontics	2.00
Periodontology	3.69

	Endo	General Dentistry	Implant	Path	Periodontology
Endodontics		0.09	0.71	0.93	0.12
General Dentistry	0.09		0.04	0.01	<0.01
Implantology	0.71	0.04		0.58	0.24
Pathology	0.93	0.01	0.58		0.05
OMR	0.22	<0.01	0.41	0.08	0.64
OMS	0.94	0.12	0.67	0.10	0.11
Orthodontics	0.37	0.01	0.60	0.23	0.51
Pedodontology	0.08	0.94	0.03	0.01	<0.01
Periodontology	0.12	<0.01	0.24	0.05	

The p-value was calculated using t statistic.

Table 14 Number of Articles by Clinical Discipline and by Efficacy Level

Clinical Discipline	Efficacy Level: Technical	Accuracy Diagnostic Thinking	Diagnostic Therapeutic	Outcome	Patient Societal	N/A	Total
Dental Public Health	0	0	0	0	1	2	3
Endodontics	0	40	12	0	1	0	133	186
General Dentistry	0	5	1	0	0	0	50	56
Implantology/ Implant Dentistry	1	27	8	0	3	0	140	179
Oral and Maxillofacial Pathology	0	2	1	0	0	0	24	27
Oral and Maxillofacial Radiology	17	201	29	4	3	0	237	491
Oral and Maxillofacial Surgery	1	21	8	2	5	0	177	214
Orthodontics and Dentofacial Orthopedics	2	64	12	2	1	0	235	316
Pediatric Dentistry	0	3	0	0	0	0	18	21
Periodontics	0	12	1	0	0	0	35	48
Prosthodontics	0	0	0	0	0	0	11	11
N/A	0	1	1	0	0	0	97	99
Total	21	376	73	8	13	1	1159	1651

Table 15 Weighted Linear Regression Analysis by Clinical Discipline and by Efficacy Level

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Pub_Year	1	1.08	1.08	15.17	<0.01
Clinical_Discipline_Code	6	2.44	0.41	5.72	<0.01
Pub_Year* Clinical_Discipline	4	0.23	0.06	0.79	0.54

Table 16 ANCOVA Pairwise Least Square Means Analysis
by Efficacy Level and Clinical Discipline

Specialty_Code	Efficacy_Level_Mean LSMEAN
Endodontics	2.25
General Dentistry	Non-est
Implantology	2.47
Oral Pathology	Non-est
OMR	2.09
OMS	2.76
Orthodontics	2.15
Pedodontics	Non-est
Periodontology	Non-est

Least Squares Means for effect Specialty_Code
Pr > |t| for H0: LSMean(i)=LSMean(j)
Dependent Variable: Efficacy_Level_Mean

i/j	Endo	General Dentistry	Implant	Pathology	OMR	OMS	Ortho	Pedodontics	Periodontology
Endo		.	0.06	.	0.07	<0.01	0.21	.	.
General Dentistry	.		.	.	.	.	.	.	.
Implant	0.06	.		.	<0.01	0.09	0.01	.	.
Pathology	.	.	.		.	.	.	.	.
OMR	0.07	.	<0.01	.		<0.01	0.47	.	.
OMS	<0.01	.	0.09	.	<0.01		<0.01	.	.
Ortho	0.21	.	0.01	.	0.47	<0.01		.	.
Pedo	.	.	.	.	.	.	.		.
Perio	.	.	.	.	.	.	.	.	

Table 17 Number of Articles by Study Design Between Radiology Journals and the Other Journals

			Year of publication											
Journal of publication			2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
Radiology Journals	Study Design	Case Report	0	1	0	0	2	2	5	4	6	1	2	23
		Case Series	0	2	0	1	1	0	1	2	2	2	0	11
		Cross-sectional	0	0	0	0	1	3	5	10	9	7	5	40
		Case-Control	0	0	0	0	0	0	0	0	1	0	1	2
		Cohort	0	0	1	0	0	0	1	0	0	0	0	2
		Experimental	0	0	0	0	1	0	0	0	1	0	1	3
		Other	2	3	0	7	13	25	25	25	34	27	29	190
	Total		2	6	1	8	18	30	37	41	53	37	38	271
Other Journals	Study Design	Case Report	0		0	1	5	18	27	33	41	57	24	206
		Case Series	0		2	1	5	4	5	6	13	19	3	58
		Cross-sectional	0		0	0	5	9	17	19	34	47	21	152
		Case-Control	0		0	0	0	0	0	0	0	1	1	2
		Cohort	0		0	0	0	0	3	0	2	3	2	10
		Experimental	0		0	0	0	0	0	1	0	3	2	6
		Other	4		6	10	28	53	113	145	186	255	146	946
	Total		4		8	12	43	84	165	204	276	385	199	1380
	Total Radiology and Other Journals		6	6	9	20	61	114	202	245	329	422	237	1651

Table 18 Weighted Linear Analyses by Journal and by Study Design

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Pub_Year	1	0.47	0.47	26.46	<0.01
Journal_Code	1	0.63	0.63	35.81	<0.01
Pub_Year*Journal_Code	1	0.02	0.02	1.23	0.30

Table 19 Number of Articles by Efficacy Level between Radiology Journals and the Other Journals

			Year of publication											
Journal of publication			2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
Radiology Journals	Efficacy Level	Technical	0	1	0	0	0	1	0	2	1	3	1	9
		Diagnostic Accuracy	1	1	0	4	8	13	17	19	16	12	12	103
		Diagnostic Thinking	0	0	1	0	1	0	2	1	2	4	1	12
		Therapeutic	0	0	0	0	0	0	0	0	1	0	1	2
		Patient Outcome	0	0	0	0	0	0	0	0	0	0	1	1
		N/A	1	4	0	4	9	16	18	19	33	18	22	144
	Total		2	6	1	8	18	30	37	41	53	37	38	271
Other Journals	Efficacy Level	Technical	0		1	0	1	1	0	1	1	4	3	12
		Diagnostic Accuracy	0		2	3	11	13	31	43	46	80	44	273
		Diagnostic Thinking	0		0	0	1	4	6	7	20	18	5	61
		Therapeutic	0		0	0	0	0	1	1	0	0	4	6
		Patient Outcome	0		0	0	0	0	3	0	1	3	5	12
		Societal	0		0	0	0	0	0	0	0	1	0	1
		N/A	4		5	9	30	66	124	152	208	279	138	1015
	Total		4		8	12	43	84	165	204	276	385	199	1380
Total	Efficacy Level	Technical	0	1	1	0	1	2	0	3	2	7	4	21
		Diagnostic Accuracy	1	1	2	7	19	26	48	62	62	92	56	376
		Diagnostic Thinking	0	0	1	0	2	4	8	8	22	22	6	73
		Therapeutic	0	0	0	0	0	0	1	1	1	0	5	8
		Patient Outcome	0	0	0	0	0	0	3	0	1	3	6	13
		Societal	0	0	0	0	0	0	0	0	0	1	0	1
		N/A	5	4	5	13	39	82	142	171	241	297	160	1159
	Total		6	6	9	20	61	114	202	245	329	422	237	1651

Table 20 Weighted Linear Analyses by Journal and by Efficacy Level

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Pub_Year	1	0.31	0.31	6.59	0.03
Journal_Code	1	0.25	0.25	5.42	0.04
Pub_Year*Journal_Cod	1	0.08	0.08	1.77	0.21

Table 21 Number of Articles by Country of Corresponding Author and Study Design

		Countries by corresponding author								
		United States of America	Brazil	Germany	United Kingdom	Japan	Turkey	South Korea	Other Countries	Total
Study Design	Case Report	66	25	23	14	14	12	15	60	229
	Case Series	17	3	6	2	7	3	3	28	69
	Cross-sectional	79	18	13	12	8	3	5	54	192
	Case-Control	1	2	0	0	0	0	0	1	4
	Cohort	4	1	0	1	1	0	2	3	12
	Experimental	5	1	0	0	0	0	0	3	9
	Other	359	113	79	68	63	59	49	346	1136
Total		531	163	121	97	93	77	74	495	1651

Table 22 Number of Articles by Country of Corresponding Author and Efficacy Level

		Top 7 countries and all others								
		Other Countries	Brazil	Germany	Japan	South Korea	Turkey	United Kingdom	United States of America	Total
Efficacy Level	Technical	11	1	1	0	0	0	2	6	21
	Diagnostic Accuracy	109	38	26	19	13	13	17	141	376
	Diagnostic Thinking	21	9	6	2	2	1	3	29	73
	Therapeutic	2	1	0	0	0	0	0	5	8
	Patient Outcome	5	4	0	0	0	0	3	1	13
	Societal	0	0	0	0	0	0	0	1	1
	N/A	347	110	88	72	59	63	72	348	1159
Total		495	163	121	93	74	77	97	531	1651

Table 23 Weighted Linear Analysis by Country and by Study Design

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Pub_Year	1	0.21	0.21	1.63	0.21
Country_Code_by_corr	7	4.13	0.59	4.61	<0.01
Pub_Year*Country_Cod	7	0.76	0.11	0.85	0.56

Table 24 ANCOVA Pairwise Least Square Means Analysis by Study Design Mean and by Country of Corresponding Author

Country_Code_by_corresponding_author	Study_Design_Mean LSMEAN
Brazil	3.28
Germany	2.75
Japan	2.73
Other	3.01
South Korea	3.20
Turkey	2.52
USA	3.29
United Kingdom	2.87

Least Squares Means for effect Country_Code_by_corr
Pr > |t| for H0: LSMean(i)=LSMean(j)
Dependent Variable: Study_Design_Mean

	Brazil	Germany	Japan	Other	South Korea	Turkey	USA	UK
Brazil		0.02	0.02	0.24	0.95	0.01	0.95	0.25
Germany	0.02		0.95	0.19	0.74	0.34	0.01	0.70
Japan	0.02	0.95		0.17	0.73	0.37	0.01	0.68
Other	0.24	0.19	0.17		0.89	0.05	0.20	0.68
South Korea	0.95	0.74	0.73	0.89		0.62	0.95	0.81
Turkey	0.01	0.34	0.37	0.05	0.62		<0.01	0.33
USA	0.95	0.01	0.01	0.20	0.95	<0.01		0.23
UK	0.25	0.70	0.68	0.68	0.81	0.33	0.23	

The p-value was calculated using t statistic.

Table 25 Weighted Linear Analyses by Country and by Efficacy Level

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Pub_Year	1	0.52	0.52	2.68	0.12
Country_Code_by_corr	7	1.99	0.28	1.46	0.24
Pub_Year*Country_Cod	5	0.89	0.18	0.91	0.49

Figures

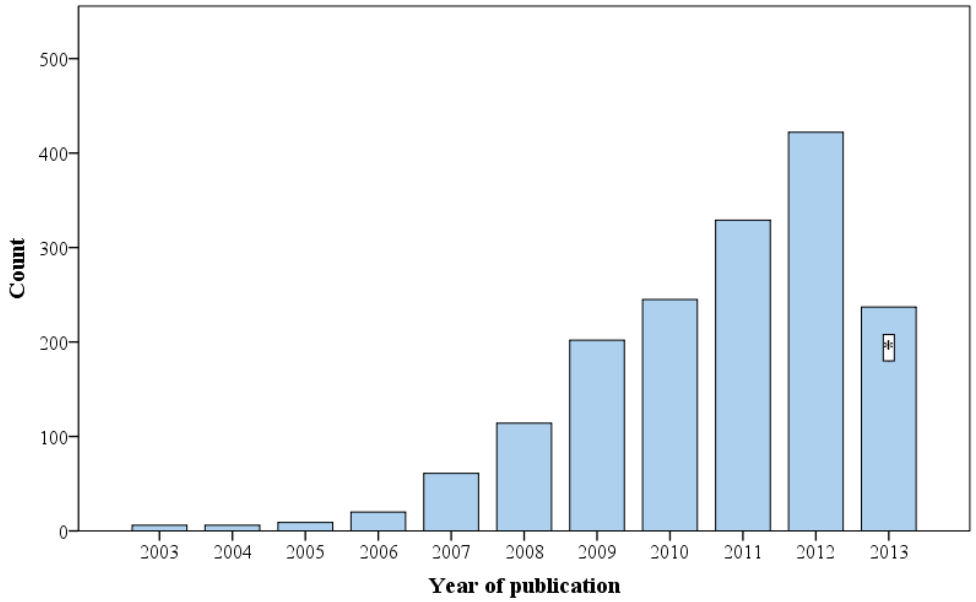


Figure 1 Total number of CBCT papers published in dental journals between 2003 and 2013 (n=1651) (*Total for 6 month in 2013) (n=237)

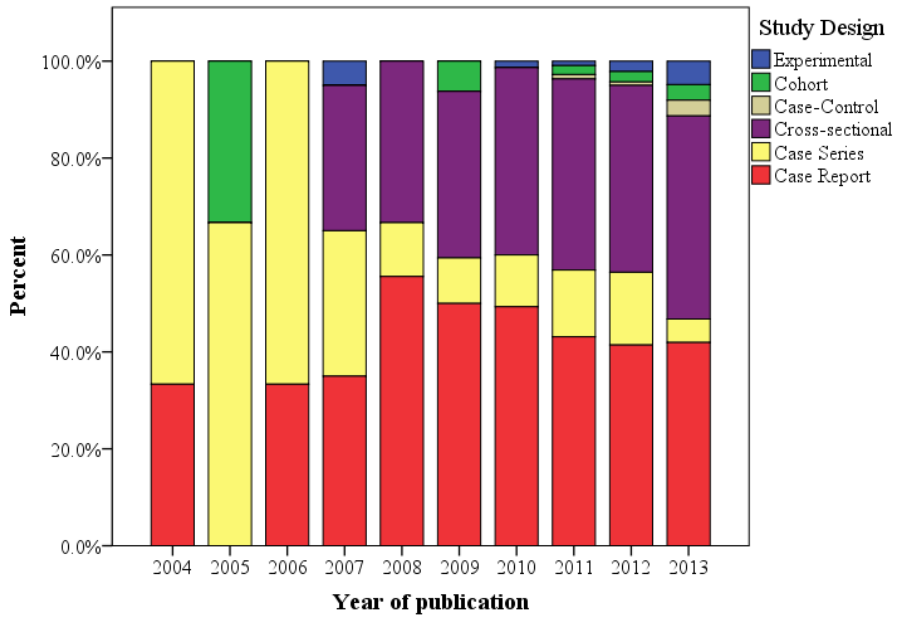


Figure 2 Percent of study designs per year between 2004 and 2013
(*2013 Totals for 6 months)

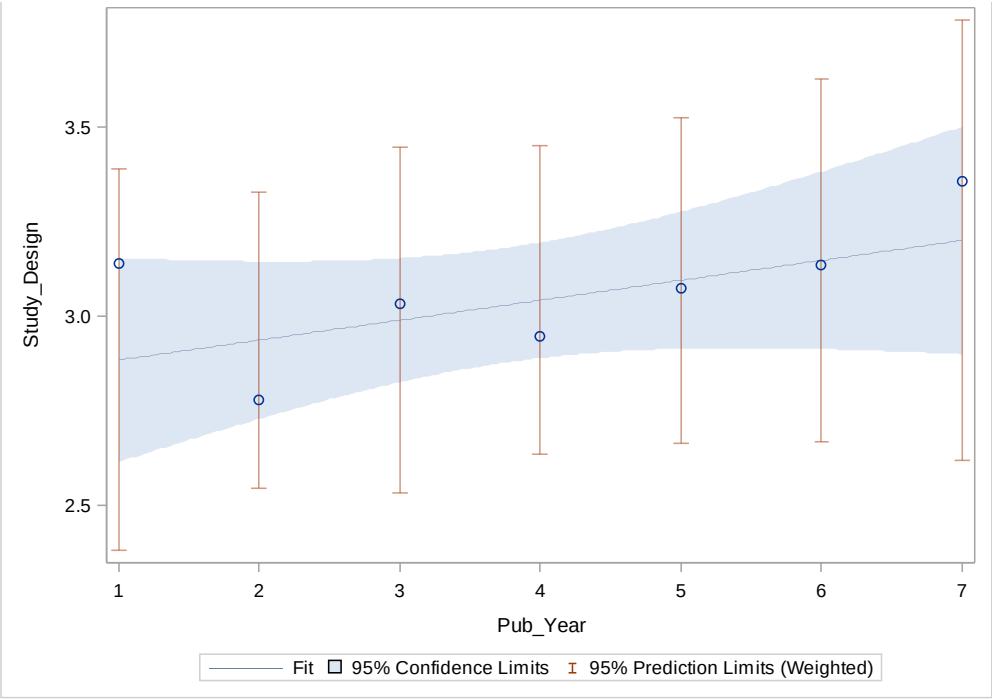


Figure 3 Plot of the means for study design over time
Pub year: 1=2007 and prior, 2=2008, 3=2009, 4=2010, 5=2011, 6=2012, 7=2013

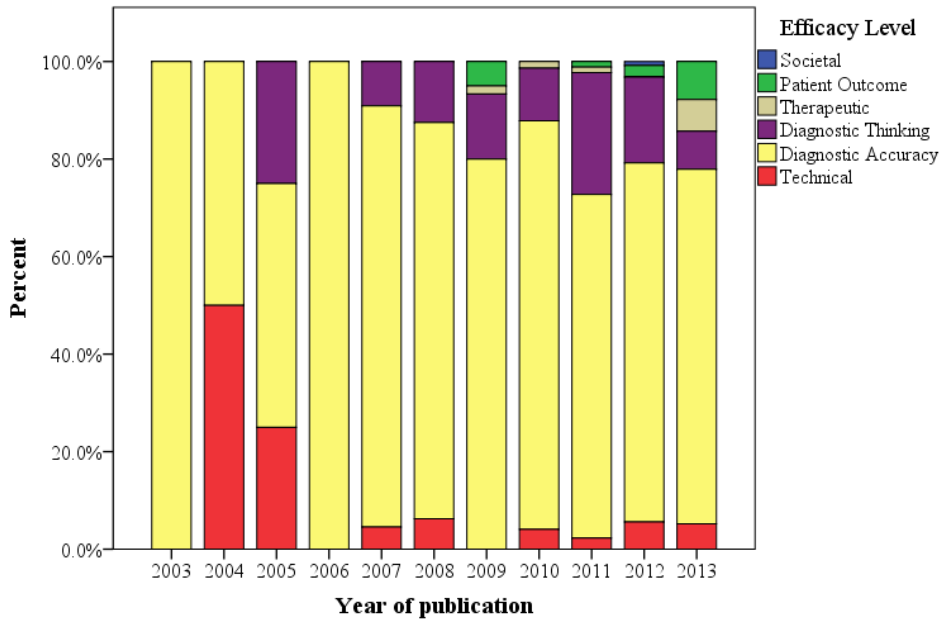


Figure 4 Percent of efficacy levels per year between 2003 and 2013
(*2013 Totals for 6 months)

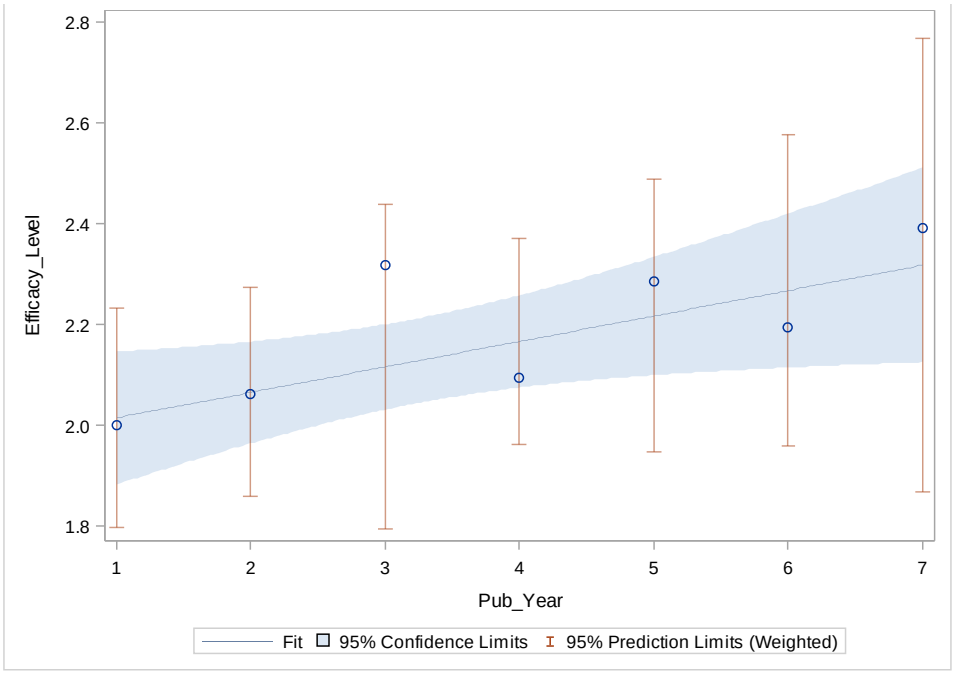


Figure 5 Fixed plot of the means for efficacy level over time
Pub year: 1=2007 and prior, 2=2008, 3=2009, 4=2010, 5=2011, 6=2012, 7=2013

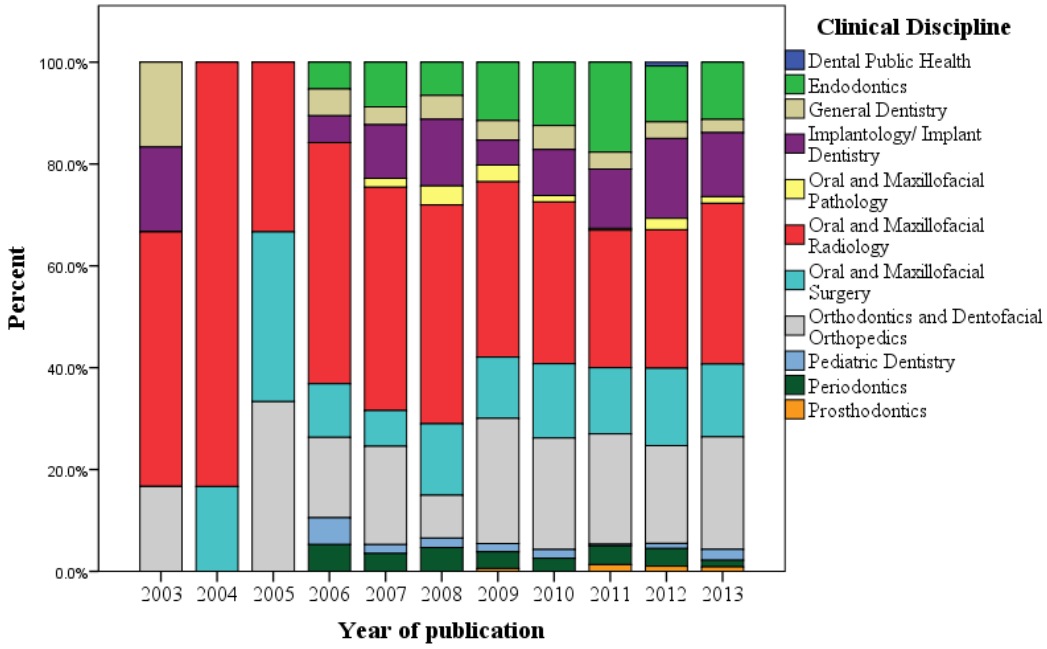


Figure 6 Percent of articles by clinical discipline by year
(*2013 Totals for 6 months)

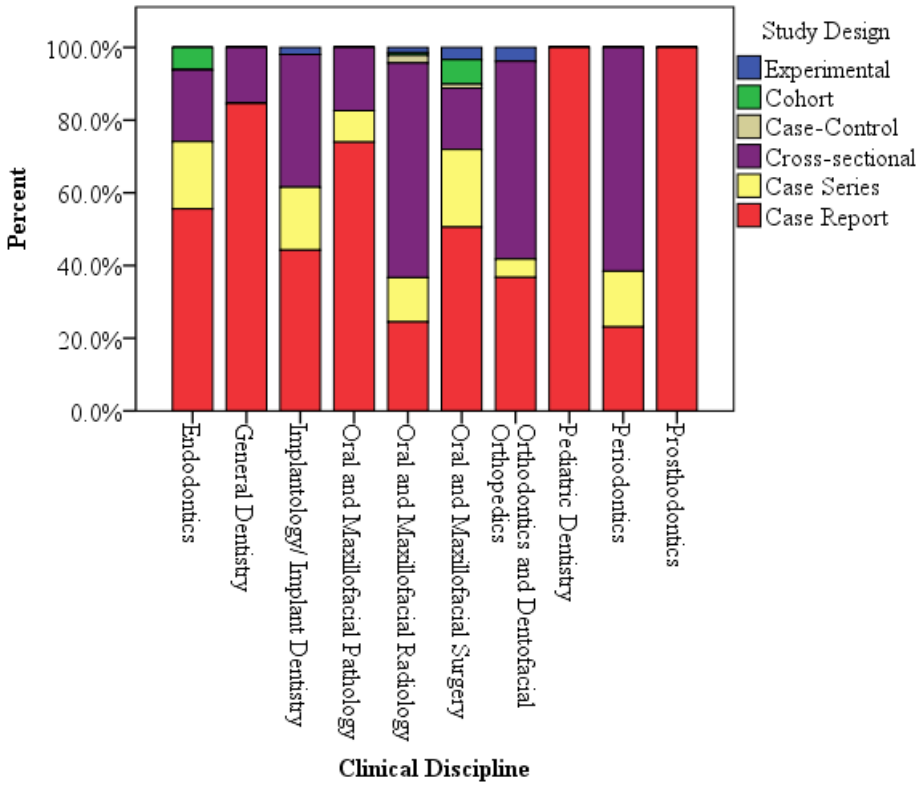


Figure 7 Percent of articles by study design for each clinical discipline
(*2013 Totals for 6 months)

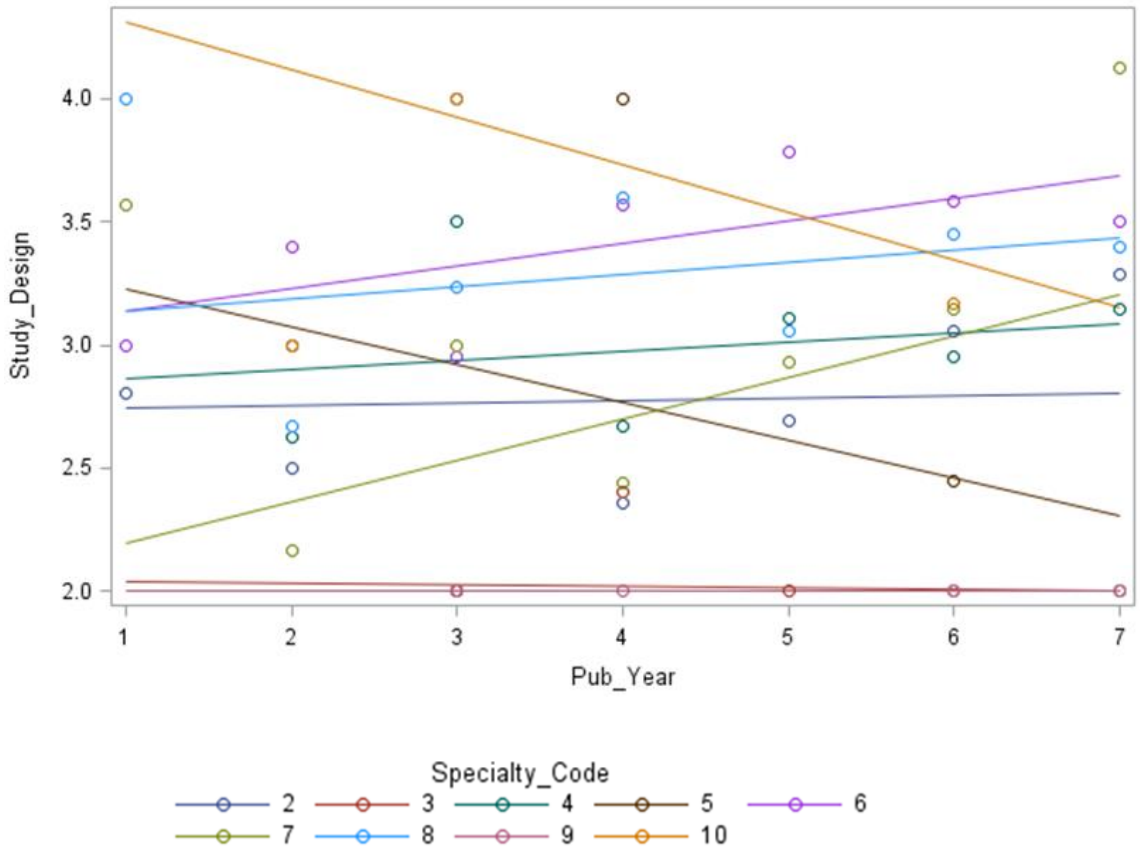


Figure 8 Fixed plot of means for each clinical discipline by study design
1=Clinical discipline codes: 2=Endodontics, 3=General Dentistry, 4=Implantology, 5=Oral Pathology, 6=Oral Radiology, 7=Oral Surgery, 8=Orthodontics, 9=Pedodontics, 10=Periodontology
Pub year: 1=2007 and prior, 2=2008, 3=2009, 4=2010, 5=2011, 6=2012, 7=2013

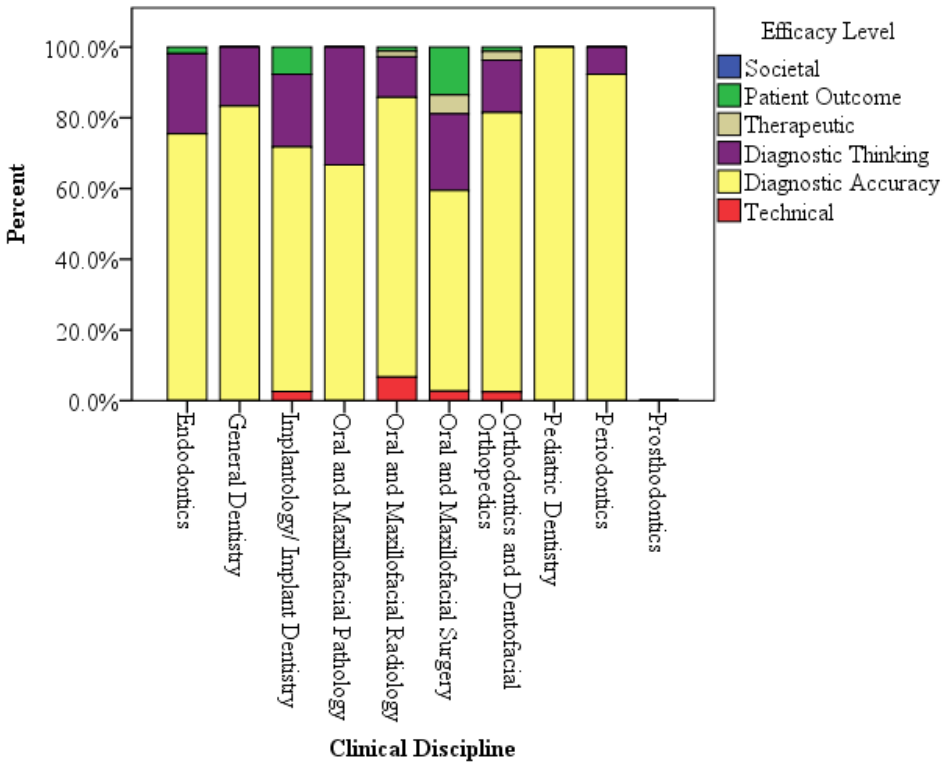


Figure 9 Percent of articles by efficacy level for each clinical discipline
(*2013 Totals for 6 months)

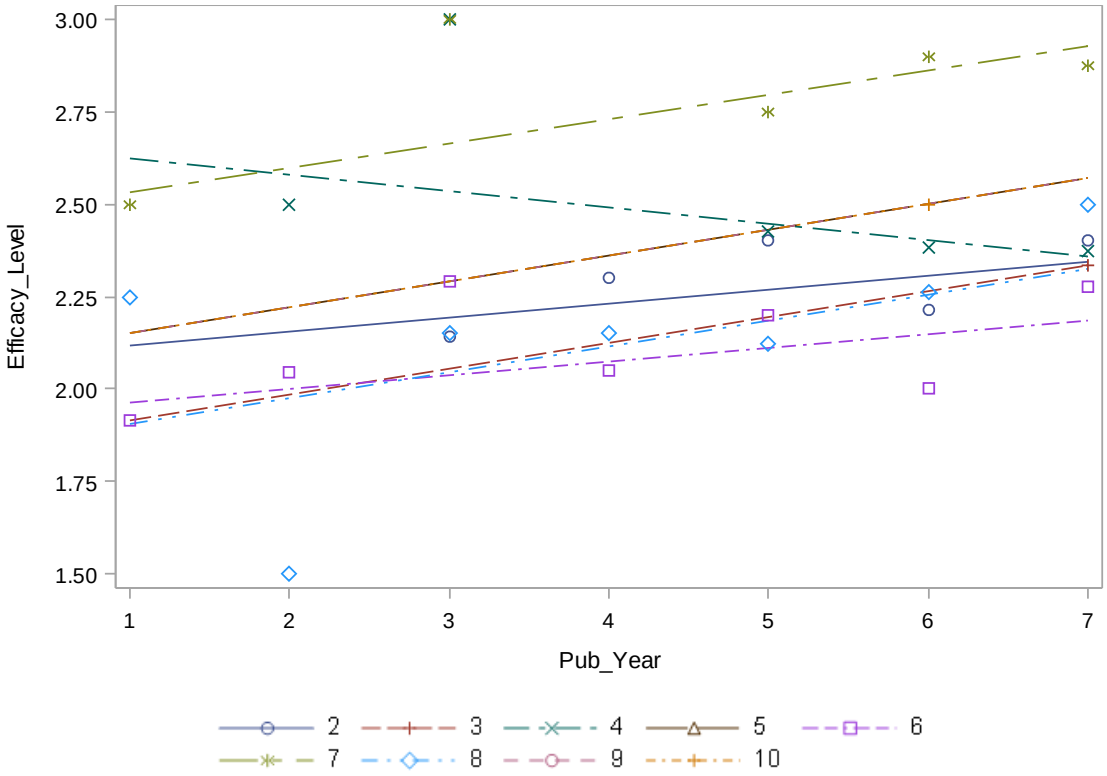


Figure 10 Fixed plot of means for each clinical discipline by efficacy level
1=Clinical discipline codes: 2=Endodontics, 3=General Dentistry, 4=Implantology, 5=Oral Pathology, 6=Oral Radiology, 7=Oral Surgery, 8=Orthodontics, 9=Pedodontics, 10=Periodontology
Pub year: 1=2007 and prior, 2=2008, 3=2009, 4=2010, 5=2011, 6=2012, 7=2013

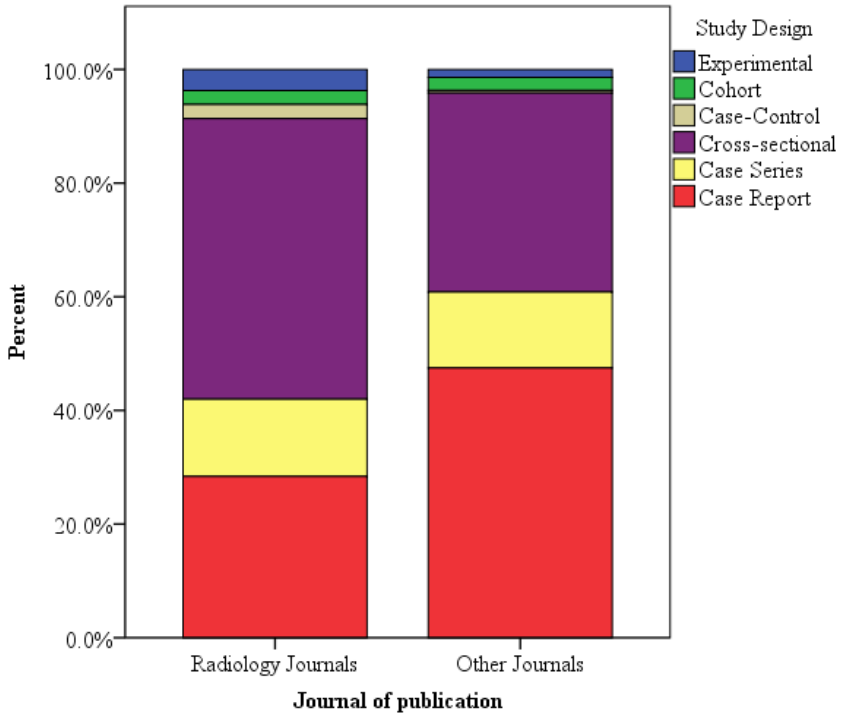


Figure 11 Percent of articles by journal and by study design
(*2013 Totals for 6 months)

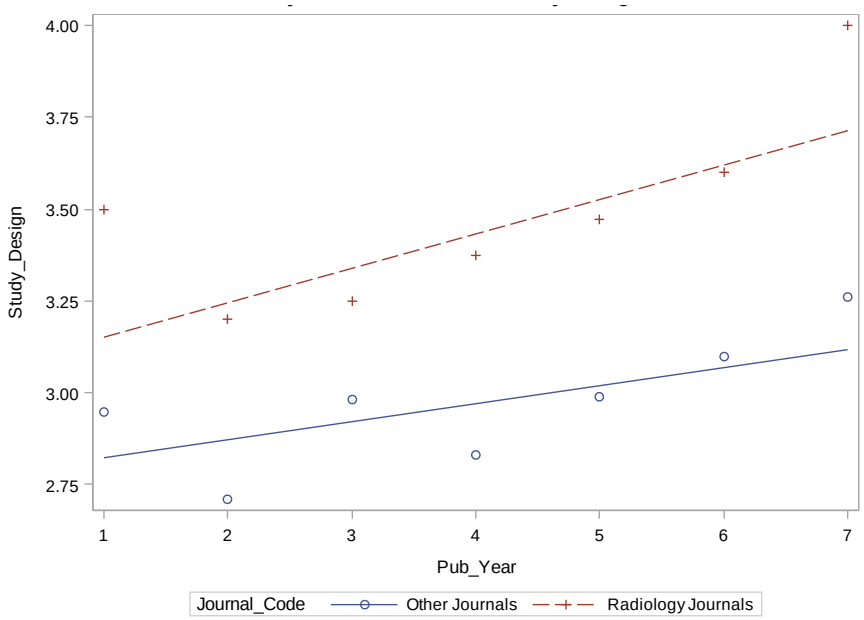


Figure 12 Fixed plot of means for radiology journals and other journals by study design
Pub year: 1=2007 and prior, 2=2008, 3=2009, 4=2010, 5=2011, 6=2012, 7=2013

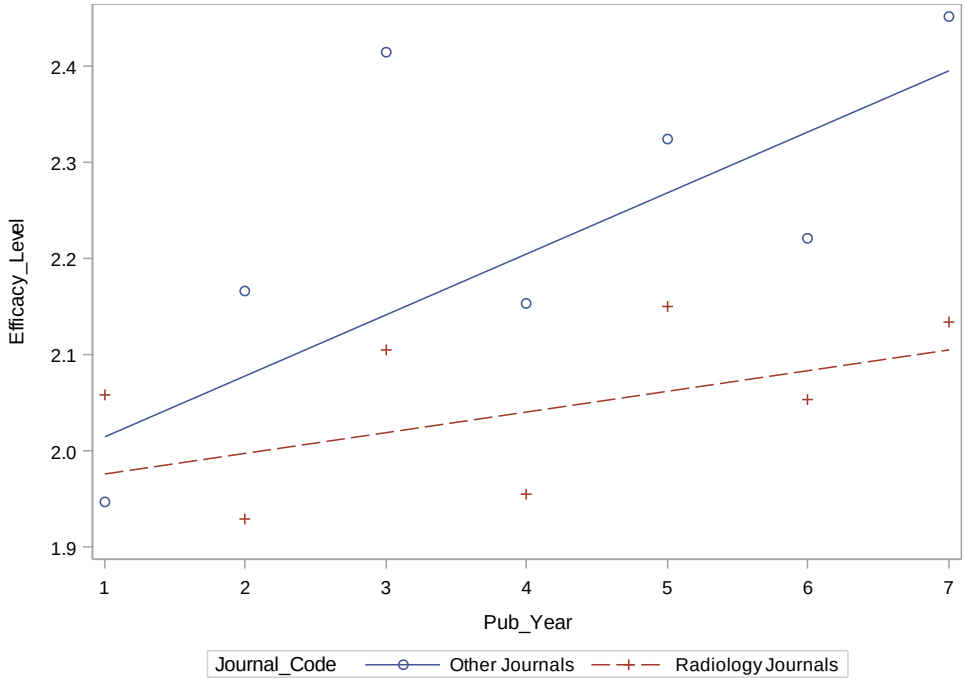


Figure 13 Fixed plot of means for radiology journals and other journals by efficacy level
Pub year: 1=2007 and prior, 2=2008, 3=2009, 4=2010, 5=2011, 6=2012, 7=2013

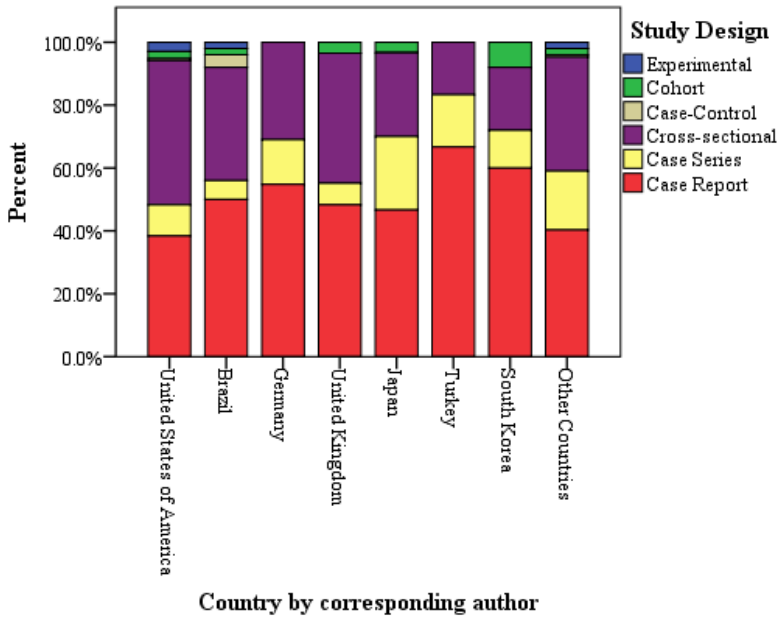


Figure 14 Percent of articles by country of corresponding author and study design (*2013 Totals for 6 months)

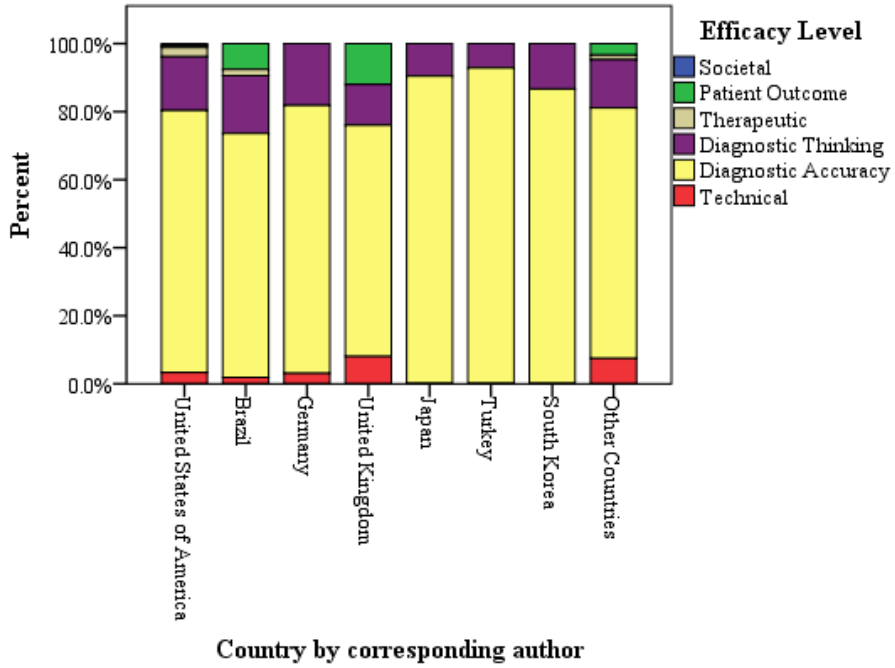


Figure 15 Percent of articles by country of corresponding author and efficacy level (*2013 Totals for 6 months)

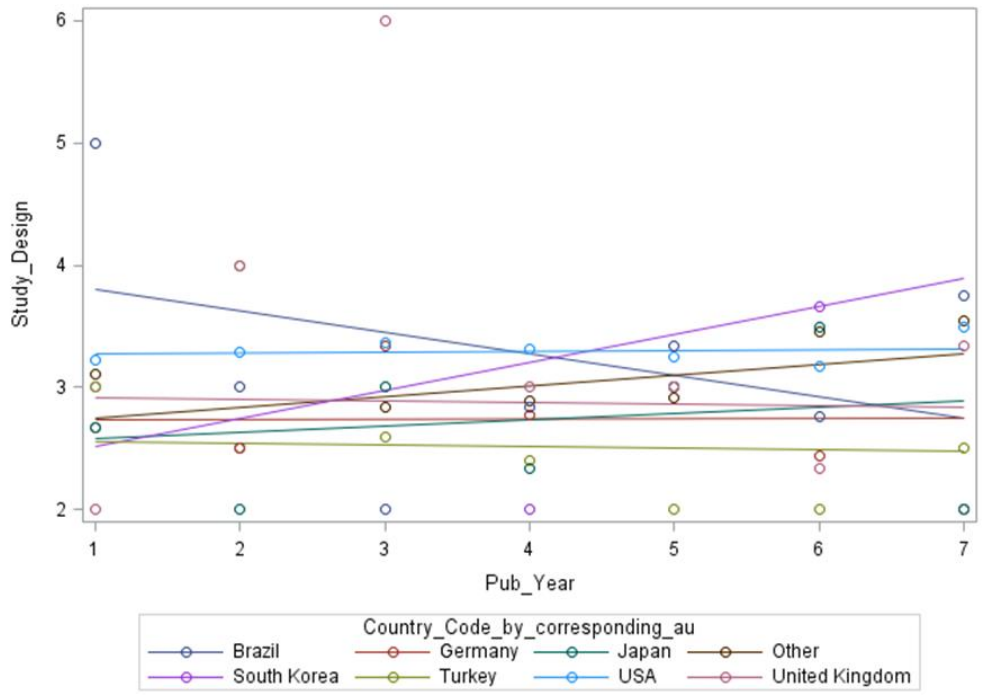


Figure 16 Fixed plot of means for country by corresponding author by study design
Pub year: 1=2007 and prior, 2=2008, 3=2009, 4=2010, 5=2011, 6=2012, 7=2013

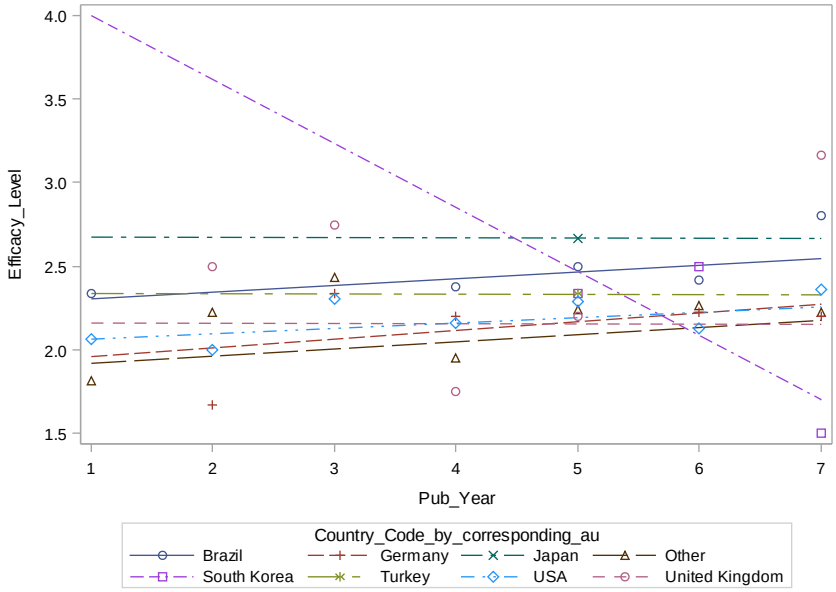


Figure 17 Fixed plot of means for country by corresponding author by efficacy level
Pub year: 1=2007 and prior, 2=2008, 3=2009, 4=2010, 5=2011, 6=2012, 7=2013

DISCUSSION

From the inception of CBCT for dentistry in the late 1990's to June 2013 when this search was completed, there has been no significant change in the types of study designs used in the clinical research published in dental journals regarding CBCT. The study designs were predominately at the lower levels of the epidemiological hierarchy with very few at the higher levels.

Case reports/series accounted for 18% of the 1651 CBCT articles published in dental journals during the study period. This is consistent with the percentage of case reports/series (21.4%) reported in a study of clinical research in oral and maxillofacial radiology published in OOOOE and DMFR.[31] Cross-sectional studies comprised 11.6% of the CBCT articles and was considerably less than the 53.9% for cross-sectional studies reported by Kim et al.[31] and the 25 to 44 per cent the Fletchers reported on the research from three general medical journals.[30] A study of research published in the neurosurgery journals, however, reported 10% for cross-sectional study designs consistent with the findings of this study. To more accurately compare the results, however, the articles from the other category needed to be removed allowing for a comparison of the articles that met the definition for CBCT research. Removing the articles from the other category and recalculating the percentages from among the articles that met this definition

resulted in 57.9% of the articles being case reports/series and 37 % of the articles being cross-sectional study designs, results more in line with the studies by the Fletchers[30] and Kim et al.[31]. A study of oral pathology papers published in 1972 and 1992 in OOOOE [34] reported that 57.8% of the pathology articles were case reports almost identical to the findings of this study. Cohort and case-control studies comprised 3.1% of the 515 articles that met the definition of CBCT research, comparable with 2.1% found in the general oral radiology literature and pediatric literature.[31, 35] At the highest level of the epidemiological hierarchy are the longitudinal studies, randomized clinical trials (RCTs) being the pinnacle and considered the gold standard, which are uncommon in the oral radiology literature. Kim et al. reported only 7 of the 384(1.8%) articles being classified as experimental studies consistent with the findings of this study of 9 out of 515(1.7%.).

There was a significant change over time in the level of efficacy in our study of the CBCT literature. This is a positive sign showing a maturation of the research with regards to CBCT. The two lowest levels of efficacy (technical and diagnostic accuracy) comprised 80.7% of the articles classified by efficacy level (n = 397 of 492, Table 9), considerably less than the general OMR literature of 96.3% for the technical and diagnostic accuracy levels. The third level of efficacy (diagnostic thinking) was considerably higher (14.8%) for CBCT than reported for the general OMR literature (1.6%).[31] Although articles at the higher levels of efficacy are rare there appears to be a positive trend in the CBCT literature. 17 of the 22 (77%) articles that were classified in the three highest efficacy levels (therapeutic patient outcome and societal) were published after 2010. Patient outcome efficacy is the efficacy level that is essential from the patients point of view according to Fryback and Thornbury[17]. Patient outcome studies accounted for 2.6% of the efficacy studies in the CBCT literature but were absent in the general

OMR literature[31]. While studies at the lower efficacy levels are necessary and foundational for studies at higher efficacy levels, studies at the higher efficacy levels are necessary for patient outcome and the benefit for society in general. For this reason it is important that studies with higher levels of efficacy are performed. The increase in efficacy found in this study, while at a significant level statistically, was primarily at the lower efficacy levels and may not be high enough to base health care policy on.

During the study period there were statistically significant differences among the clinical disciplines for study design. Five of the clinical disciplines (Endodontics, Implantology, OMR, OMS and Orthodontics) accounted for 84% of the articles that were published over the time frame of this study. The significant differences were mainly between these five major contributors and the other clinical disciplines. There was and outlier, however, Periodontology with only 13 articles that were classified by study design and had the highest overall average mean study design. This was a result of eight out of thirteen articles having a cross-sectional study design and could represent a small sample bias. Considering that there were not any statistical differences between the clinical disciplines publishing the majority of the work, it can be concluded that there is no clinically significant difference between the study designs by clinical discipline. While there was not a statistically significant difference between the slopes of the lines for disciplines, a difference can be visually appreciated, with Oral Maxillofacial Surgery having the greatest slope, indicating an increased trend toward higher study designs. This increase was to be expected with the increasing integration of CBCT into the clinical practice of Oral Maxillofacial Surgery and the accompanying research for those clinical applications. The negative slope for Oral Maxillofacial Pathology can best be explained by the simple fact that the articles were categorized by the general topic of the articles. If the article was

in OOOOE and had a joint radiology/pathology emphasis the evaluator did not break down the journal by section but most likely defaulted to Oral Maxillofacial Radiology. This could have contributed to the low sampling frequency that was present for Oral Pathology resulting in this random effect.

When comparing efficacy levels by clinical discipline, a statistically significant difference was found between Oral Maxillofacial Surgery and Oral Maxillofacial Radiology and between Oral Maxillofacial Surgery and Orthodontics. A significant difference was also found between Implantology and Oral Maxillofacial Radiology, between Implantology and Orthodontics and between Endodontics and OMS. The differences between clinical disciplines by efficacy levels can best be explained by the emphasis of the clinical disciplines. When CBCT was first introduced to dentistry, Oral Maxillofacial Radiology was tasked with determining the safety and accuracy of this new imaging modality. These studies are all at the lowest two levels of the hierarchy and account for the majority of the early studies. As new scanners and/or techniques are introduced, the same low level studies must be repeated to assure safety and accuracy. Orthodontics, like radiology, has well established diagnostic tasks that are image related. Like radiology, when new technology is introduced to accomplish these tasks, studies aimed at accuracy and safety for the patients is needed. These studies are at the lower efficacy levels and need to be repeated for each differing task and method of analysis. The plots of the efficacy means by clinical discipline demonstrate a positive trend in all clinical disciplines except Implantology. The negative trend in efficacy levels for Implantology is best explained by clinical application and the recent use of CBCT for guided implant surgery. Like radiology and orthodontics the lower levels of efficacy are necessary to ensure safety and accuracy for implants placement as new techniques are introduced.

The differences between the Radiology journals and the Other Journals found in this study support the discussion about clinical discipline emphasis that was presented in regards to clinical discipline. The significant differences for both study design and efficacy level between the journals fell in line with the emphasis of the specialties that publish articles in their respective journals. The overall mean for study design was higher for Radiology Journals and the overall mean for efficacy was higher for Other Journals. Radiology has been involved in CBCT research since its introduction to dentistry. The maturation of studies over time lends toward higher study designs because the Radiology Journals decline studies that present the same levels of evidence with redundant information of less interest to their readers. Many of the journals in the Other Journal category are clinically based journals. In order to keep up with the rapid change in radiology technology clinically based journal may move on to new techniques and procedures without pursuing more rigorous studies of the existing technology. The fear of getting left behind and the pressure to appeal to the readership demanding information regarding new technology may also contribute to this problem. This could discourage the initiation of future research resulting in research that stays at the lower evidence levels.

The statistical difference in efficacy between Radiology Journals and the Other Journals is consistent with research questions that need to be answered. Research in radiology is very technical, answering questions concerning physical parameters and answering questions concerning accuracy. A large number of articles regarding this research are at the lower efficacy levels and tend to be published in Radiology Journals. The more clinically based disciplines, which publish in the other journals, tend to deal with the higher efficacy levels of diagnosis, treatment planning and patient outcome. While the trends for journals by study design and

efficacy levels over time were not significantly different, the regression lines for both categories indicate a trend toward higher study designs and higher levels of efficacy.

With regards to country by corresponding author there were statistically significant differences between countries by study design. The differences were between the two countries with the two highest overall means (Brazil and USA) and the countries with the countries with the three lowest overall means. However, the number of articles at the higher levels of evidence for all countries remain sparse and are all but absent at the RCT level. The statistically significant finding between the countries is not a clinically significant finding due to the fact that the differences remain mainly between the lower levels of evidence. Brazil had the highest overall mean for study design. However, Brazil was the only country to show a negative trend in study design over time. There could be many reasons for this trend, however, one reason as suggested by the Fletchers is academic pressure, the "publish or perish" feeling [30], and the fact that studies at more rigorous levels are expensive, slow and difficult. As educational programs are established in Oral Maxillofacial Radiology there is also the time constraint that comes with completing your program/training on time that could potentially limit more rigorous studies.

One thing that could have affected the results of this study was the use of the dental journal filter. Restricting the CBCT literature by the dental journal filter in pub med resulted in some articles being excluded. The initial search results did not return any results for articles prior to 2003. When the search was repeated without the dental journal filter for the period prior to 2003 there were a total of 8 articles published, 5 articles in non-dental journals and 3 in dental journals, which were excluded from our sample. An advanced search in Pub med identified 289 articles that were excluded by the dental journal filter from inception to June of 2013 and the evaluator manually went through all of these articles. 219 articles were published in non-dental

journal; however, the remaining 70 articles were published in dental journals. Consulting with a senior research librarian at the Health Science Library it was discovered that journals have to be registered as dental journal in Pub med and if this step was missed it could account for the missing articles. All 70 of the articles were then classified by study design and efficacy level to evaluate any potential impact they might have had on the project. Classification Resulted in 18 articles that met the criteria for classification by study design, 12 were case reports, and 6 were cross-sectional study designs. Only 8 of the 70 articles were classified by efficacy level and all were classified as diagnostic accuracy efficacy level. The use of the dental journal filter should not bias the results, as the results from the subset are consistent with the overall sample.

The present study is a follow up study to a study published in DMFR in 2015[31] that analyzed the general OMR literature by study design and efficacy level. To our knowledge a complete analysis of the CBCT literature for dentistry by this same model has not been completed. While there were some differences with regards to statistically significant increases in efficacy level between this study and the study of the general OMR literature the fact remains that the majority of the articles are still at the lower levels of efficacy.

In conclusion even though there was a significant difference in efficacy levels over time the majority of the articles published in the dental journals regarding CBCT remain at the weaker study designs and the lower levels of efficacy. The significant differences between clinical disciplines and Journals for both study design and efficacy level can be attributed to emphasis of the clinical discipline and the journals respectively and these overall differences were all at the lower levels indicating no clinically significant difference. The significant differences between counties by study design did not result in significant studies at the experimental level for any country indicating no clinical significance between countries. Differences in study design and

efficacy, over the time of this study, between clinical disciplines, journals and countries was not significant. The positive trends and small improvements from the general OMR literature are encouraging, however, the majority of the research remains at the lower levels and research with stronger study designs and higher levels of efficacy are needed in the future.

APPENDIX 1

Journal Codes			
Journal	Code	Journal	Code
Acta Odontologica Latinoamericana : AOL	1	Journal of orthodontics	59
American Journal of Orthodontics and Dentofacial Orthopedics	2	Journal of periodontology	60
Atlas of the Oral and Maxillofacial Surgery Clinics of North America	3	Journal of prosthodontics : official journal of the American College of Prosthodontists	61
Australian Dental Journal	4	Journal of the American Dental Association	62
Australian Endodontic Journal	5	Journal of the California Dental Association	63
Australian Orthodontic Journal	6	Journal of the Indian Society of Pedodontics and Preventive Dentistry	64
BMC oral health	7	Journal of the International Academy of Periodontology	65
Brazilian dental journal	8	Journal of the Irish Dental Association	66
Brazilian oral research	9	Journal of the Massachusetts Dental Society	67
British dental journal	10	Journal of the New Jersey Dental Association	68
Caries research	11	Journal of veterinary dentistry	69
Clinical implant dentistry and related research	12	Medicina oral, patologia oral y cirugia buccal	70
Clinical oral implants research	13	Minerva stomatologica	71
Clinical oral investigations	14	Northwest dentistry	72
Community dentistry and oral epidemiology	15	Operative dentistry	73
Compendium of continuing education in dentistry	16	Oral and maxillofacial surgery	74
Cranio : the journal of craniomandibular practice	17	Oral and maxillofacial surgery clinics of North America	75
Dental clinics of North America	18	Oral surgery, oral medicine, oral pathology and oral radiology	76
Dental implantology update	19	Oral surgery, oral medicine, oral pathology, oral radiology, and endodontics	77
Dental materials : official publication of the Academy of Dental Materials	20	Orthodontics & craniofacial research	78

		Association	
International journal of orthodontics (Milwaukee, Wis.)	41	The European journal of esthetic dentistry : official journal of the European Academy of Esthetic Dentistry	99
International orthodontics / College europeen d'orthodontie	42	The International journal of oral & maxillofacial implants	100
Journal - Oklahoma Dental Association	43	The International journal of periodonology & restorative dentistry	101
Journal (Canadian Dental Association)	44	The International journal of prosthodontics	102
Journal (Indiana Dental Association)	45	The Journal of clinical pediatric dentistry	103
Journal of applied oral science : revista FOB	46	The journal of contemporary dental practice	104
Journal of clinical orthodontics : JCO	47	The Journal of craniofacial surgery	105
Journal of clinical periodontology	48	The journal of evidence-based dental practice	106
Journal of cranio-maxillo-facial surgery : official publication of the European Association for Cranio-Maxillo-Facial Surgery	49	The Journal of forensic odonto-stomatology	107
Journal of dental education	50	The Journal of oral implantology	108
Journal of dentistry	51	The Journal of prosthetic dentistry	109
Journal of endodontics	52	The Journal of the American College of Dentists	110
Journal of esthetic and restorative dentistry : official publication of the American Academy of Esthetic Dentistry	53	The Journal of the Michigan Dental Association	111
Journal of oral and maxillofacial surgery: official journal of the American Association of Oral and Maxillofacial Surgeons	54	The Journal of the Western Society of Periodontology/Periodontal abstracts	112
Journal of oral rehabilitation	55	The New York state dental journal	113
Journal of oral science	56	The New Zealand dental journal	114
Journal of orofacial orthopedics = Fortschritte der Kieferorthopadie : Organ/official journal	57	Today's FDA : official monthly journal of the Florida Dental Association	115
Journal of orofacial pain	58	World journal of orthodontics	116

APPENDIX 2

TABLE OF ARTICLES BY CLINICAL DISCIPLINE BY YEAR AND STUDY DESIGN

			Year of publication											
Clinical Discipline			2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
Dental Public	Study	Other										**3**		**3**
Health	Design													
	Total											**3**		**3**
Endodontics	Study	Case Report				**0**	**1**	**3**	**1**	**11**	**16**	**10**	**3**	**45**
	Design													
		Case Series				**1**	**3**	**0**	**0**	**1**	**8**	**1**	**1**	**15**
		Cross-sectional				**0**	**0**	**1**	**2**	**2**	**4**	**5**	**2**	**16**
		Cohort				**0**	**0**	**0**	**1**	**0**	**1**	**2**	**1**	**5**
		Other				**0**	**1**	**3**	**17**	**15**	**24**	**26**	**19**	**105**
	Total					**1**	**5**	**7**	**21**	**29**	**53**	**44**	**26**	**186**
General	Study	Case Report	**0**			**0**	**0**	**0**	**2**	**4**	**3**	**2**	**0**	**11**
Dentistry	Design	Cross-sectional	**0**			**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**2**
		Other	**1**			**1**	**2**	**5**	**5**	**6**	**7**	**11**	**5**	**43**
	Total		**1**			**1**	**2**	**5**	**7**	**11**	**10**	**13**	**6**	**56**
Implantology/	Study	Case Report	**0**			**0**	**0**	**5**	**1**	**2**	**3**	**8**	**4**	**23**
Implant	Design	Case Series	**0**			**0**	**0**	**1**	**0**	**0**	**2**	**5**	**1**	**9**
Dentistry		Cross-sectional	**0**			**0**	**1**	**2**	**3**	**1**	**4**	**7**	**1**	**19**
		Experimental	**0**			**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**
		Other	**1**			**1**	**5**	**6**	**5**	**18**	**26**	**43**	**22**	**127**
	Total		**1**			**1**	**6**	**14**	**9**	**21**	**35**	**63**	**29**	**179**
Oral and	Study	Case Report					**1**	**1**	**5**	**0**	**1**	**6**	**3**	**17**
Maxillofacial	Design	Case Series					**0**	**0**	**0**	**0**	**0**	**2**	**0**	**2**
Pathology		Cross-sectional					**0**	**1**	**0**	**2**	**0**	**1**	**0**	**4**
		Other					**0**	**2**	**1**	**1**	**0**	**0**	**0**	**4**
	Total						**1**	**4**	**6**	**3**	**1**	**9**	**3**	**27**
Oral and	Study	Case Report	**0**	**1**	**0**	**0**	**2**	**2**	**11**	**4**	**4**	**4**	**6**	**34**
Maxillofacial	Design	Case Series	**0**	**1**	**0**	**0**	**1**	**2**	**2**	**4**	**2**	**5**	**0**	**17**
Radiology		Cross-sectional	**0**	**0**	**0**	**0**	**3**	**6**	**7**	**12**	**20**	**22**	**12**	**82**
		Case-Control	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**2**	**3**
		Cohort	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**1**
		Experimental	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**2**
		Other	**3**	**3**	**3**	**9**	**19**	**36**	**42**	**53**	**53**	**78**	**53**	**352**

	Total		**3**	**5**	**3**	**9**	**25**	**46**	**63**	**74**	**81**	**109**	**73**	**491**
Oral and	Study	Case Report		**0**	**0**	**0**	**0**	**5**	**6**	**11**	**8**	**13**	**2**	**45**
Maxillofacial	Design	Case Series		**1**	**1**	**1**	**2**	**1**	**2**	**3**	**2**	**6**	**0**	**19**
Surgery		Cross-sectional		**0**	**0**	**0**	**1**	**0**	**0**	**2**	**4**	**4**	**4**	**15**
		Case-Control		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**
		Cohort		**0**	**1**	**0**	**0**	**0**	**2**	**0**	**1**	**1**	**1**	**6**
		Experimental		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**1**	**3**
		Other		**0**	**1**	**1**	**1**	**9**	**12**	**18**	**24**	**34**	**25**	**125**
	Total			**1**	**3**	**2**	**4**	**15**	**22**	**34**	**39**	**61**	**33**	**214**
Orthodontics	Study	Case Report	**0**		**0**	**0**	**1**	**2**	**4**	**2**	**9**	**7**	**4**	**29**
and Dentofacial	Design	Case Series	**0**		**1**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**1**	**4**
Orthopedics		Cross-sectional	**0**		**0**	**0**	**1**	**1**	**7**	**8**	**10**	**12**	**4**	**43**
		Experimental	**0**		**0**	**0**	**1**	**0**	**0**	**0**	**0**	**1**	**1**	**3**
		Other	**1**		**2**	**3**	**8**	**6**	**32**	**41**	**46**	**57**	**41**	**237**
	Total		**1**		**3**	**3**	**11**	**9**	**45**	**51**	**65**	**77**	**51**	**316**
Pediatric	Study	Case Report				**1**	**0**	**0**	**2**	**2**	**1**	**2**	**4**	**12**
Dentistry	Design	Other				**0**	**1**	**2**	**1**	**2**	**0**	**2**	**1**	**9**
	Total					**1**	**1**	**2**	**3**	**4**	**1**	**4**	**5**	**21**
Periodontology	Study	Case Report				**0**	**0**	**1**	**0**	**0**	**0**	**2**	**0**	**3**
	Design													
		Case Series				**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**2**
		Cross-sectional				**0**	**0**	**1**	**3**	**1**	**0**	**3**	**0**	**8**
		Other				**1**	**2**	**3**	**3**	**5**	**10**	**8**	**3**	**35**
	Total					**1**	**2**	**5**	**6**	**6**	**11**	**14**	**3**	**48**
Prosthodontics	Study	Case Report							**0**		**2**	**1**	**0**	**3**
	Design													
		Other							**1**		**2**	**3**	**2**	**8**
	Total								**1**		**4**	**4**	**2**	**11**
N/A	Study	Case Report				**0**	**2**	**1**	**0**	**1**	**0**	**3**	**0**	**7**
	Design													
		Case Series				**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**
		Cross-sectional				**0**	**0**	**0**	**0**	**0**	**1**	**0**	**2**	**3**
		Other				**1**	**2**	**6**	**19**	**11**	**28**	**17**	**4**	**88**
	Total					**1**	**4**	**7**	**19**	**12**	**29**	**21**	**6**	**99**
	Totals for all clinical disciplines		**6**	**6**	**9**	**20**	**61**	**114**	**202**	**245**	**329**	**422**	**237**	**1651**

APPENDIX 3

NUMBER OF ARTICLES BY CLINICAL DISCIPLINE, EFFICACY AND YEAR

			Year of publication											
Clinical Discipline			2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
Dental Public Health	Efficacy	Societal										**1**		**1**
	Level	N/A										**2**		**2**
	Total											**3**		**3**
Endodontics	Efficacy	Diagnostic				**0**	**0**	**2**	**6**	**7**	**6**	**11**	**8**	**40**
	Level	Accuracy												
		Diagnostic				**0**	**0**	**0**	**1**	**3**	**4**	**3**	**1**	**12**
		Thinking												
		Patient				**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**
		Outcome												
		N/A				**1**	**5**	**5**	**14**	**19**	**43**	**30**	**16**	**133**
	Total					**1**	**5**	**7**	**21**	**29**	**53**	**44**	**26**	**186**
General Dentistry	Efficacy	Diagnostic	**0**			**1**	**0**	**0**	**0**	**1**	**0**	**1**	**2**	**5**
	Level	Accuracy												
		Diagnostic	**0**			**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**
		Thinking												
		N/A	**1**			**0**	**2**	**5**	**7**	**10**	**10**	**12**	**3**	**50**
	Total		**1**			**1**	**2**	**5**	**7**	**11**	**10**	**13**	**6**	**56**
Implantology/	Efficacy	Technical	**0**			**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**
Implant Dentistry	Level	Diagnostic	**0**			**0**	**2**	**1**	**2**	**3**	**4**	**10**	**5**	**27**
		Accuracy												
		Diagnostic	**0**			**0**	**0**	**1**	**1**	**0**	**3**	**2**	**1**	**8**
		Thinking												
		Patient	**0**			**0**	**0**	**0**	**1**	**0**	**0**	**1**	**1**	**3**
		Outcome												
		N/A	**1**			**1**	**4**	**12**	**5**	**18**	**28**	**50**	**21**	**140**
	Total		**1**			**1**	**6**	**14**	**9**	**21**	**35**	**63**	**29**	**179**
Oral and	Efficacy	Diagnostic					**0**	**0**	**0**	**2**	**0**	**0**	**0**	**2**
Maxillofacial	Level	Accuracy												
Pathology		Diagnostic					**0**	**1**	**0**	**0**	**0**	**0**	**0**	**1**
		Thinking												
		N/A					**1**	**3**	**6**	**1**	**1**	**9**	**3**	**24**
	Total						**1**	**4**	**6**	**3**	**1**	**9**	**3**	**27**

Oral and Maxillofacial Radiology	Efficacy Level	Technical	**0**	**1**	**1**	**0**	**0**	**1**	**0**	**3**	**2**	**7**	**2**	**17**
		Diagnostic Accuracy	**1**	**1**	**1**	**5**	**14**	**18**	**25**	**31**	**33**	**44**	**28**	**201**
		Diagnostic Thinking	**0**	**0**	**0**	**0**	**0**	**2**	**4**	**5**	**9**	**7**	**2**	**29**
		Therapeutic	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**0**	**2**	**4**
		Patient Outcome	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**2**	**3**
		N/A	**2**	**3**	**1**	**4**	**11**	**25**	**32**	**35**	**36**	**51**	**37**	**237**
	Total		**3**	**5**	**3**	**9**	**25**	**46**	**63**	**74**	**81**	**109**	**73**	**491**
Oral and Maxillofacial Surgery	Efficacy Level	Technical		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**
		Diagnostic Accuracy		**0**	**0**	**0**	**1**	**1**	**2**	**4**	**4**	**6**	**3**	**21**
		Diagnostic Thinking		**0**	**1**	**0**	**0**	**0**	**0**	**0**	**3**	**3**	**1**	**8**
		Therapeutic		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**2**
		Patient Outcome		**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**2**	**1**	**5**
		N/A		**1**	**2**	**2**	**3**	**14**	**19**	**30**	**31**	**50**	**25**	**177**
	Total			**1**	**3**	**2**	**4**	**15**	**22**	**34**	**39**	**61**	**33**	**214**
Orthodontics and Dentofacial Orthopedics	Efficacy Level	Technical	**0**		**0**	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**2**
		Diagnostic Accuracy	**0**		**1**	**0**	**0**	**1**	**11**	**12**	**14**	**17**	**8**	**64**
		Diagnostic Thinking	**0**		**0**	**0**	**2**	**0**	**2**	**0**	**2**	**6**	**0**	**12**
		Therapeutic	**0**		**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**2**
		Patient Outcome	**0**		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**
		N/A	**1**		**2**	**3**	**8**	**7**	**32**	**38**	**49**	**54**	**41**	**235**
	Total		**1**		**3**	**3**	**11**	**9**	**45**	**51**	**65**	**77**	**51**	**316**
Pediatric Dentistry	Efficacy Level	Diagnostic Accuracy				**0**	**1**	**0**	**0**	**1**	**0**	**1**	**0**	**3**
		N/A				**1**	**0**	**2**	**3**	**3**	**1**	**3**	**5**	**18**
	Total					**1**	**1**	**2**	**3**	**4**	**1**	**4**	**5**	**21**
Periodontology	Efficacy Level	Diagnostic Accuracy				**1**	**1**	**3**	**2**	**1**	**1**	**1**	**2**	**12**
		Diagnostic Thinking				**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**

		N/A				**0**	**1**	**2**	**4**	**5**	**10**	**12**	**1**	**35**
	Total					**1**	**2**	**5**	**6**	**6**	**11**	**14**	**3**	**48**
Prosthodontics	Efficacy Level	N/A							**1**		**4**	**4**	**2**	**11**
	Total								**1**		**4**	**4**	**2**	**11**
N/A	Efficacy Level	Diagnostic Accuracy				**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**
		Diagnostic Thinking				**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**
		N/A				**1**	**4**	**7**	**19**	**12**	**28**	**20**	**6**	**97**
	Total					**1**	**4**	**7**	**19**	**12**	**29**	**21**	**6**	**99**
	Totals for all clinical disciplines		**6**	**6**	**9**	**20**	**61**	**114**	**202**	**245**	**329**	**422**	**237**	**1651**

APPENDIX 4

NUMBER OF ARTICLES BY COUNTRY OF CORRESPONDING AUTHOR AND STUDY DESIGN

			Year of publication											
Coutry by corresponding author			2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
Argentina	Study Design	Other									**1**	**1**		**2**
	Total										**1**	**1**		**2**
Australia	Study Design	Case Report					**0**	**0**	**1**	**0**	**0**	**0**	**0**	**1**
		Case Series					**0**	**0**	**0**	**0**	**0**	**1**	**1**	**2**
		Other					**1**	**1**	**2**	**1**	**6**	**2**	**2**	**15**
	Total						**1**	**1**	**3**	**1**	**6**	**3**	**3**	**18**
Austria	Study Design	Cross-sectional								**0**	**1**		**0**	**1**
		Other								**1**	**0**		**2**	**3**
	Total									**1**	**1**		**2**	**4**
Belgium	Study Design	Case Report				**0**	**1**	**1**	**2**	**1**	**1**	**0**	**0**	**6**
		Case Series				**0**	**1**	**0**	**0**	**0**	**1**	**0**	**0**	**2**
		Cross-sectional				**0**	**1**	**1**	**0**	**1**	**3**	**1**	**1**	**8**
		Cohort				**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**1**
		Other				**1**	**1**	**3**	**7**	**4**	**5**	**7**	**5**	**33**
	Total					**1**	**4**	**5**	**10**	**6**	**10**	**8**	**6**	**50**
Brazil	Study Design	Case Report			**0**	**0**	**0**	**2**	**4**	**3**	**3**	**10**	**3**	**25**
		Case Series			**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**0**	**3**
		Cross-sectional			**0**	**0**	**1**	**2**	**0**	**2**	**4**	**6**	**3**	**18**
		Case-Control			**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**2**

		Cohort	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**
		Experimental	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**
		Other	**0**	**2**	**4**	**8**	**18**	**16**	**23**	**25**	**17**	**113**
	Total		**1**	**2**	**5**	**12**	**22**	**22**	**32**	**42**	**25**	**163**
Canada	Study Design	Case Report				**0**	**1**	**1**	**2**	**1**	**1**	**6**
		Cross-sectional				**0**	**0**	**0**	**0**	**2**	**1**	**3**
		Other				**2**	**3**	**6**	**2**	**10**	**4**	**27**
	Total					**2**	**4**	**7**	**4**	**13**	**6**	**36**
Chile	Study Design	Cross-sectional						**0**		**0**	**1**	**1**
		Other						**1**		**1**	**0**	**2**
	Total							**1**		**1**	**1**	**3**
China	Study Design	Case Report	**0**		**0**	**1**	**0**	**0**	**1**	**0**	**3**	**5**
		Case Series	**0**		**0**	**0**	**1**	**0**	**0**	**1**	**1**	**3**
		Cross-sectional	**0**		**0**	**1**	**0**	**0**	**3**	**3**	**2**	**9**
		Cohort	**0**		**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**
		Other	**2**		**1**	**1**	**4**	**7**	**14**	**13**	**5**	**47**
	Total		**2**		**1**	**3**	**5**	**7**	**18**	**18**	**11**	**65**
Denmark	Study Design	Case Report			**1**	**1**	**2**	**0**	**1**	**1**	**0**	**6**
		Case Series			**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**
		Cross-sectional			**0**	**0**	**0**	**0**	**1**	**0**	**1**	**2**
		Other			**0**	**0**	**0**	**1**	**2**	**3**	**0**	**6**
	Total				**1**	**1**	**2**	**1**	**4**	**5**	**1**	**15**
Egypt	Study Design	Case Report				**1**	**0**		**2**	**0**	**0**	**3**
		Case-Control				**0**	**0**		**0**	**0**	**1**	**1**
		Other				**0**	**2**		**0**	**2**	**0**	**4**
	Total					**1**	**2**		**2**	**2**	**1**	**8**

Finland	Study Design	Case Series			**1**	**0**	**0**			**0**	**1**
		Other			**0**	**1**	**1**			**2**	**4**
	Total				**1**	**1**	**1**			**2**	**5**
France	Study Design	Case Report	**0**			**0**	**0**	**1**	**0**	**1**
		Other	**1**			**1**	**2**	**2**	**1**	**7**
	Total		**1**			**1**	**2**	**3**	**1**	**8**
Germany	Study Design	Case Report	**1**	**3**	**2**	**4**	**4**	**7**	**2**	**23**
		Case Series	**2**	**0**	**0**	**3**	**1**	**0**	**0**	**6**
		Cross-sectional	**0**	**1**	**4**	**2**	**4**	**2**	**0**	**13**
		Other	**3**	**7**	**10**	**16**	**18**	**15**	**10**	**79**
	Total		**6**	**11**	**16**	**25**	**27**	**24**	**12**	**121**
Greece	Study Design	Case Report	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**2**
		Case Series	**0**	**1**	**1**	**0**	**1**	**2**	**0**	**5**
		Cross-sectional	**1**	**0**	**1**	**0**	**0**	**1**	**0**	**3**
		Other	**0**	**1**	**1**	**2**	**0**	**0**	**1**	**5**
	Total		**1**	**2**	**4**	**2**	**1**	**3**	**2**	**15**
Hungary	Study Design	Cross-sectional				**1**	**0**	**0**		**1**
		Other				**0**	**1**	**1**		**2**
	Total					**1**	**1**	**1**		**3**
India	Study Design	Case Report	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**2**
		Case Series	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**1**
		Cross-sectional	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**2**
		Other	**1**	**1**	**2**	**3**	**2**	**1**	**6**	**2**	**18**
	Total		**1**	**1**	**2**	**5**	**2**	**2**	**8**	**2**	**23**
Iran	Study Design	Case Report				**0**	**0**	**0**	**1**	**0**	**1**

		Case Series						**0**	**1**	**0**	**0**	**0**	**1**
		Cross-sectional						**0**	**0**	**1**	**0**	**1**	**2**
		Other						**1**	**1**	**4**	**3**	**1**	**10**
	Total							**1**	**2**	**5**	**4**	**2**	**14**
Israel	Study Design	Case Report						**0**	**0**			**1**	**1**
		Other						**1**	**4**			**0**	**5**
	Total							**1**	**4**			**1**	**6**
Italy	Study Design	Case Report		**0**			**0**	**0**	**1**	**0**	**1**	**0**	**0**	**2**
		Case Series		**0**			**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**
		Cross-sectional		**0**			**0**	**0**	**0**	**1**	**0**	**1**	**1**	**3**
		Experimental		**0**			**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**
		Other		**2**			**3**	**1**	**1**	**5**	**4**	**8**	**4**	**28**
	Total			**2**			**3**	**1**	**2**	**6**	**6**	**10**	**5**	**35**
Japan	Study Design	Case Report	**0**		**0**	**1**	**0**	**1**	**2**	**2**	**2**	**2**	**4**	**14**
		Case Series	**0**		**0**	**0**	**2**	**0**	**1**	**1**	**0**	**3**	**0**	**7**
		Cross-sectional	**0**		**0**	**0**	**0**	**0**	**2**	**0**	**2**	**4**	**0**	**8**
		Cohort	**0**		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**
		Other	**1**		**1**	**1**	**3**	**3**	**7**	**11**	**15**	**14**	**7**	**63**
	Total		**1**		**1**	**2**	**5**	**4**	**12**	**14**	**19**	**24**	**11**	**93**
Latvia	Study Design	Other											**2**	**2**
	Total												**2**	**2**
Lebanon	Study Design	Case Report										**1**		**1**
	Total											**1**		**1**
Netherlands	Study Design	Case Report	**0**	**0**		**0**	**0**	**0**	**0**	**2**	**2**	**1**	**0**	**5**

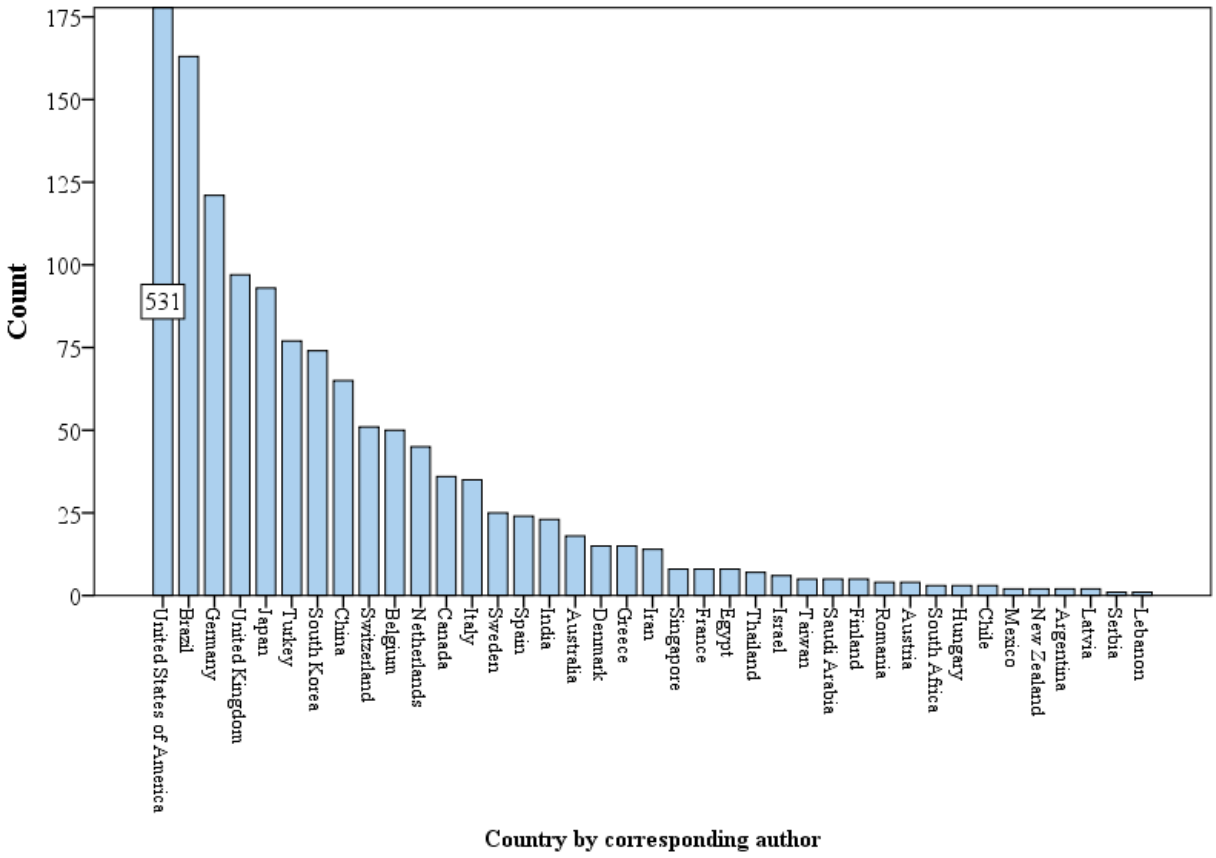
		Case Series	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**2**
		Cross-sectional	**0**	**0**	**0**	**1**	**0**	**1**	**0**	**2**	**2**	**0**	**6**
		Cohort	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**
		Experimental	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**2**
		Other	**1**	**1**	**0**	**0**	**1**	**0**	**5**	**7**	**7**	**7**	**29**
	Total		**1**	**1**	**1**	**1**	**1**	**1**	**7**	**11**	**12**	**9**	**45**
New Zealand	Study Design	Other					**1**			**1**			**2**
	Total						**1**			**1**			**2**
Romania	Study Design	Case Report						**1**	**0**	**1**	**0**		**2**
		Other						**0**	**1**	**0**	**1**		**2**
	Total							**1**	**1**	**1**	**1**		**4**
Saudi Arabia	Study Design	Cross-sectional				**0**		**1**		**0**		**0**	**1**
		Other				**1**		**1**		**1**		**1**	**4**
	Total					**1**		**2**		**1**		**1**	**5**
Serbia	Study Design	Other								**1**			**1**
	Total									**1**			**1**
Singapore	Study Design	Case Report						**0**	**0**	**1**		**0**	**1**
		Case Series						**0**	**0**	**1**		**0**	**1**
		Cross-sectional						**0**	**1**	**0**		**0**	**1**
		Other						**1**	**1**	**2**		**1**	**5**
	Total							**1**	**2**	**4**		**1**	**8**
South Korea	Study Design	Case Report		**0**			**5**	**1**	**2**	**3**	**3**	**1**	**15**
		Case Series		**0**			**0**	**0**	**1**	**0**	**2**	**0**	**3**
		Cross-sectional		**0**			**0**	**0**	**3**	**0**	**1**	**1**	**5**
		Cohort		**0**			**0**	**1**	**0**	**1**	**0**	**0**	**2**

		Other		1			1	6	6	10	15	10	49
	Total			1			6	8	12	14	21	12	74
Spain	Study Design	Case Report	0			0			2	0	0	0	2
		Case Series	1			0			0	0	1	0	2
		Cross-sectional	0			0			0	0	2	0	2
		Other	0			1			0	10	3	4	18
	Total		1			1			2	10	6	4	24
Switzerland	Study Design	Case Report		0	0	0	2	2	3	2	0	0	9
		Case Series		1	0	0	1	0	0	0	0	0	2
		Cross-sectional		0	0	0	0	1	0	0	1	0	2
		Other		0	1	3	3	2	3	5	17	4	38
	Total			1	1	3	6	5	6	7	18	4	51
Sweden	Study Design	Case Report					1	1	0	1	0	0	3
		Case Series					0	0	0	0	1	0	1
		Cross-sectional					1	0	0	1	4	1	7
		Other					3	0	1	5	4	1	14
	Total						5	1	1	7	9	2	25
Taiwan	Study Design	Case Series				1				0	1		2
		Other				0				2	1		3
	Total					1				2	2		5
Thailand	Study Design	Case Report							0	1	0	0	1
		Other							3	1	1	1	6
	Total								3	2	1	1	7
Turkey	Study Design	Case Report		0	0	0	0	3	4	2	2	1	12
		Case Series		1	0	0	0	1	0	0	0	1	3

		Cross-sectional			**0**	**0**	**0**	**1**	**1**	**1**	**0**	**0**	**0**	**3**
		Other			**0**	**1**	**1**	**4**	**4**	**17**	**16**	**12**	**4**	**59**
	Total				**1**	**1**	**1**	**5**	**9**	**22**	**18**	**14**	**6**	**77**
United Kingdom	Study Design	Case Report	**0**		**0**	**0**	**1**	**0**	**0**	**3**	**3**	**5**	**2**	**14**
		Case Series	**0**		**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**2**
		Cross-sectional	**0**		**0**	**0**	**0**	**1**	**0**	**3**	**3**	**1**	**4**	**12**
		Cohort	**0**		**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**1**
		Other	**2**		**1**	**1**	**3**	**6**	**15**	**5**	**12**	**9**	**14**	**68**
	Total		**2**		**1**	**1**	**4**	**7**	**16**	**11**	**20**	**15**	**20**	**97**
United States of America	Study Design	Case Report	**0**	**1**	**0**	**0**	**3**	**2**	**7**	**10**	**14**	**22**	**7**	**66**
		Case Series	**0**	**1**	**0**	**1**	**0**	**1**	**0**	**1**	**7**	**6**	**0**	**17**
		Cross-sectional	**0**	**0**	**0**	**0**	**2**	**4**	**11**	**14**	**17**	**22**	**9**	**79**
		Case-Control	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**
		Cohort	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**1**	**1**	**4**
		Experimental	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**1**	**1**	**1**	**5**
		Other	**1**	**0**	**1**	**9**	**15**	**29**	**48**	**48**	**48**	**98**	**62**	**359**
	Total		**1**	**2**	**1**	**10**	**21**	**36**	**67**	**74**	**88**	**151**	**80**	**531**
South Africa	Study Design	Case Series						**0**	**1**			**0**		**1**
		Other						**1**	**0**			**1**		**2**
	Total							**1**	**1**			**1**		**3**
Mexico	Study Design	Other									**1**		**1**	**2**
	Total										**1**		**1**	**2**
Total	Study Design	Case Report	**0**	**1**	**0**	**1**	**7**	**20**	**32**	**37**	**47**	**58**	**26**	**229**
		Case Series	**0**	**2**	**2**	**2**	**6**	**4**	**6**	**8**	**15**	**21**	**3**	**69**

	Cross-sectional	**0**	**0**	**0**	**0**	**6**	**12**	**22**	**29**	**43**	**54**	**26**	**192**
	Case-Control	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**2**	**4**
	Cohort	**0**	**0**	**1**	**0**	**0**	**0**	**4**	**0**	**2**	**3**	**2**	**12**
	Experimental	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**1**	**3**	**3**	**9**
	Other	**6**	**3**	**6**	**17**	**41**	**78**	**138**	**170**	**220**	**282**	**175**	**1136**
Total		**6**	**6**	**9**	**20**	**61**	**114**	**202**	**245**	**329**	**422**	**237**	**1651**

APPENDIX 5



Bar graph of the number of articles by country of corresponding author

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