A systematic review of Swedish research in orthodontics during the past decade

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The aims of this systematic review were to identify the study designs and topics of Swedish orthodontic articles, to elucidate their international position, and to verify in which scientific journals the articles had been published in the past decade. A search of the Medline database for papers published between 1992 and 2002 was made using the Medical Search Heading terms 'orthodontics', 'malocclusion', 'cephalometry', and 'facial bones and growth'. Two independent reviewers selected the articles of Swedish origin and categorized each article according to research design and principal topic. Overall, 15,571 articles in orthodontic research were found, and the Swedish contribution was 1.9% with the majority of these (71.5%) being submitted by universities. Most of the Swedish articles (84.5%) had been published in 10 journals and many high-quality studies with orthodontic interest were published in non-orthodontic journals with higher impact factor scores than the orthodontic journals. Every second study was prospective, and of these, 15 (5.2% of all Swedish articles) were randomized clinical trials (RCTs). It was found that nearly every third study, prospective as well as retrospective, was uncontrolled. The main classification was treatment studies (51.9%), followed by development (18.6%) and diagnostic information (10.7%) studies. Thus, the majority of the articles evaluated therapeutic interventions; however, although the RCT is the preferred study design in evaluation studies, few used this method. In an era focused on evidence-based medicine, studies with an RCT design will be the future challenge for research in the field of orthodontics. □ *Bibliometrics; evidence-based medicine; information science; medical informatics; study design*

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In the field of orthodontics, the term 'state of the art' has long been the standard for clinicians in the treatment of malocclusions. However, advancements in the discipline of orthodontics may today depend more on scientific development than on the refinement of artistic talents (1, 2). Clinical research in orthodontics has always been complex, because answers must be sought against a background of patient variation, impact on continued growth, a multitude of appliance systems, and variations in patient compliance with the treatment regimens. Improvements in orthodontic practice depend on the continued accumulation and synthesis of new knowledge, and research should provide sound data on which clinicians may rely when making treatment decisions (3). With increasing emphasis on the development of evidence-based clinical decision-making, more focus is being placed on the availability of high quality evidence (4–7).

The role of scientific dental journals is to support clinicians by presenting evidence that can be used when choosing the most favorable patient care and differentiating between useful and useless information (8). Evidence-based medicine can be one way to approach this concept, and is 'the conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients' (5). According to this concept, well-designed, randomized clinical trials (RCTs) provide more reliable evidence than uncontrolled studies and expert opinions. However, the optimal study design will vary with the defined aims, e.g. for prognosis studies or when morphological development is studied the optimal study design is a prospective controlled cohort study.

In a recent study it was shown that the number of publications in dental research had decreased between 1966 and 1999. In addition, clinical trials, RCTs, and meta-analyses were not well represented (9). In another report on the period between 1981 and 1997, it was found that Swedish dental research has a strong position in an international perspective. However, the relative impact (citations/paper) of Swedish papers in the past 10 years has tended to decrease (10).

In light of this, it was important to examine the Swedish contribution to scientific knowledge in the field of orthodontics. Therefore, the aim of this systematic review was to identify the study designs and topics as well as elucidate the international standing of Swedish orthodontic articles, and verify in which scientific journals the articles had been published in the past decade.

Methods

Studies on orthodontic research were identified in a literature search of the Medline database (Entrez PubMed, www.ncbi.nim.nih.gov/PubMed/) by one of the authors (LB). The search covered the period from 1 January 1992 to 31 December 2002 and was made using the Medical

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Search Heading (MeSH) terms 'orthodontics', 'malocclusion', 'cephalometry', and 'facial bones and growth'. These MeSH terms were deemed most relevant for identifying orthodontic articles (11).

The total and the annual number of orthodontic articles was calculated. Two independent reviewers (LB, ELK) determined which articles were of Swedish origin. The reviewers then categorized the Swedish articles according to research design and principal topic. The results of selection and categorization were compared and inter-examiner disagreements were solved by discussion to reach a consensus. The number of Swedish publications per journal was determined. The origin of the Swedish articles was assessed using the 'home basis', i.e. the institutional affiliation of the authors. University publications (Göteborg, Malmö, Stockholm, and Umeå) were separated from publications by clinics with no university affiliation.

To provide a quantitative tool for ranking and comparing journals, the impact factor (IF) was investigated for each journal. A journal's IF represents the number of times it is cited in other journals divided by the number of articles it published during a 2-year period; numbers below a certain threshold are not reported, so those journals do not have an IF. Thus, the journal IF is based on information obtained from citation indexes and in this study the most commonly used index, the Science Citation Index introduced by the Institute for Scientific Information (ISI), was applied. Since the ISI index is a retrospective index of a journal's short-term impact and this study covered a period of a decade, the average IF over all years of ISI quotation (1974–2001) was chosen to better evaluate each journal.

The definition of research design was modified according to Green & Byar (12) and Harrison et al. (13). Thus, the articles were classified into (a) RCTs with participants randomly allocated; (b) prospective studies where the hypothesis was posed before data collection; (c) retrospective studies where the analyzed data had been collected before the hypothesis was posed; (d) epidemiological studies, i.e. reports of the prevalence or incidence of patient characteristics in a population; (e) reviews considered to be either a systematic or an unsystematic appraisal of published literature; (f) opinions, i.e. an author's view of clinical practice; and (g) case reports, i.e. reports of the outcome of treatment or features of less than 6 cases. All studies were further classified as (i) controlled trials (with concurrent untreated or normal controls), (ii) trials comparing at least 2 treatment strategies, and (iii) uncontrolled trials (no concurrently untreated or normal controls).

Categorization of the topics investigated in each article was modified according to Harrison et al. (13). The articles were grouped into the following categories: (a_t) treatment studies, usually the evaluation of therapeutic intervention with specific appliances; (b_t) animal studies, the outcome of experimentation on animals or tissue cultures; (c_t) developmental studies, characteristics or parameters in untreated humans; (d_t) studies considering diagnostic information, typically establishment of cephalometric norms for groups of patients; (e_t) studies on the services, features, and provisions of clinical services; and (f_t) studies related to education, e.g. clinical training.

Table 1. Annual numbers of orthodontic publications world-wide and in Sweden from the period 1992 to 2002. The percentage of Swedish publications of all orthodontic publications is given in parentheses

	Orthodontic publications world-wide	Swedish publications		
		Total	University	Clinics
2002	1,576	16 (1.0%)	11	5
2001	1,536	20 (1.3%)	14	6
2000	1,481	32 (2.2%)	21	11
1999	1,453	25 (1.7%)	15	10
1998	1,507	42 (2.8%)	26	16
1997	1,486	21 (1.4%)	13	8
1996	1,393	31 (2.2%)	22	9
1995	1,425	36 (2.5%)	30	6
1994	1,306	24 (1.8%)	22	2
1993	1,233	19 (1.5%)	16	3
1992	1,176	25 (2.1%)	18	7
Total	15,572	291 (1.9%)	208	83

Results

The inter-examiner agreement on articles of Swedish origin was over 98%, and the classifications concerning study design and topic were identical in 85%. In the remaining 15% of the articles where the two observers differed, the inter-examiner disagreements were solved by discussion to reach a consensus. Nearly 70% of the disagreements were whether the study design was prospective or retrospective and 30% of the disagreements concerned whether the paper should be placed under the topic development or diagnostic information. The amount of orthodontic literature was quantified by the search strategy used. In the period between 1 January 1966 and 31 December 2002, 50,623 articles were published on orthodontic research. In the past decade, 1 January 1992 to 31 December 2002, 15,572 articles in orthodontic research were published, 291 (1.9%) of which were of Swedish origin (Table 1). During the period, the average number of Swedish publications per year was 26.5 (standard deviation (*s*) 7.94) with a maximum of 42 in 1998 and a minimum of 16 in 2002 (Table 1). It was found that 71.5% ($n = 208$) of the Swedish articles came from universities. The dental clinics, predominantly orthodontic clinics, contributed 28.5% ($n = 83$). Of the university publications, Göteborg University contributed 36.5% ($n = 76$), Karolinska Institutet, Stockholm 30.5% ($n = 64$), Malmö University 18.5% ($n = 38$), and Umeå University 14.5% ($n = 30$).

The Swedish orthodontic research was published in 42 journals and 56.4% of the articles were published in orthodontic journals, while 43.6% were published in non-

Table 2. The 10 journals in which most Swedish orthodontic articles over the period 1 January 1992 to 31 December 2002 were published. The average impact factor (IF) over all years of the Institute for Scientific Information (ISI) quotation (1974–2001) is given for each journal

Abbreviated journal title	No. of articles	Average impact factor (IF)
Eur J Orthod	72	0.52
Am J Orthod Dentofac Orthop	48	0.62
Swed Dent J	37	0.77
Acta Odontol Scand	26	0.73
Angle Orthod	16	0.43
J Orofac Orthop	13	No IP
Scand J Plast Reconstr Surg Hand Surg	10	0.43
J Orthod/Br J Orthod	9	No IP
Cleft Pal Cranio Fac J	8	0.72
Eur J Oral Sci	7	1.17

orthodontic journals (28.2% in journals for general dentistry and 15.5% in medical journals). Table 2 lists the 10 journals that published the greatest numbers of Swedish articles over the period; these journals were the source of 84.5% (246 of 291) of Swedish research.

Only 3 orthodontic journals (*American Journal of Orthodontics and Dentofacial Orthopedics*, *European Journal of Orthodontics*, and *The Angle Orthodontist*) have an IF that is considered significant enough to be estimated each year by the Institute for Scientific Information (ISI). The average IF of the orthodontic journals ranged from 0.43 (*The Angle Orthodontist*) to 0.62 (*American Journal of Orthodontics and Dentofacial Orthopedics*). As a comparison, the average IF range of the non-orthodontic journals was 0.30 (*Growth Development Aging*) to 1.85 (*Journal of Clinical Periodontology*). Thus, 34% of the articles with orthodontic interest were published in non-orthodontic journals with an average IF higher than the orthodontic journals. It can also be added that 11% of the articles were published in journals with no IP.

Nearly every second study was prospective, of which a minor part were RCTs. In one-third of the studies the design was retrospective (Table 3). In 31.3% (78 of 249) of the prospective and retrospective studies, control groups, i.e. concurrent untreated or normal controls, were used while 35.7% (89 of 249) of the studies used comparison groups, where for example at least two treatment strategies were compared. It was found that 32.9% (82 of 249) of the studies were uncontrolled. Almost 9% (8.6%) of the articles were reviews, of which none were systematic or meta-analyses. Epidemiological articles, case reports, and opinions comprised a minor part (5.8%) of the publications (Table 3). The comparative number of prospective studies (including RCTs) submitted by universities (109 of 208) and clinics (41 of 83) was fairly equal, while relatively more retrospective studies were submitted by the clinics. On the other hand, review articles were more often produced at the universities (Table 3).

The distribution of topics among the articles is given in Table 4. The main topic was classified as treatment studies

Table 3. Study design of Swedish publications in orthodontics during the period 1 January 1992 to 31 December 2002. Number and percent of each category of design as well as distribution of number and percent between universities and clinics

Design	Total	Universities	Clinics
RCT	15 (5.2%)	7 (2.4%)	8 (2.7%)
Prospective	135 (46.4%)	102 (35.1%)	33 (11.3%)
Retrospective	99 (34.0%)	65 (22.3%)	34 (11.7%)
Reviews	25 (8.6%)	23 (7.9%)	2 (0.7%)
Epidemiological	3 (1.0%)	1 (0.3%)	2 (0.7%)
Case reports	11 (3.8%)	7 (2.4%)	4 (1.4%)
Opinions	3 (1.0%)	3 (1.0%)	0 (0.0%)
Total	291 (100.0%)	208 (71.5%)	83 (28.5%)

(51.9%), followed by development (18.6%) and diagnostic information (10.7%) studies. Few publications considered animal or tissue culture studies (9.3%) or material studies (5.5%), while even fewer studies were related to services (3.0%) and education (1.0%).

At the universities, treatment studies dominated (46.7%), followed by development (19.2%), diagnostic information (13.5%), and animal studies (12.5%). At dental clinics the majority of research concerned treatment (65.1%) followed by development (16.9%).

Discussion

In this systematic review of Swedish research in orthodontics during the past decade the Medline database (Entrez PubMed, www.ncbi.nlm.nih.gov/PubMed/) was chosen since this is the National Library of Medicine's premier bibliographic database for medicine, nursing, dentistry, veterinary medicine, the health care system, and the preclinical sciences. It contains bibliographic citations and author abstracts from more than 4600 biomedical journals published in the United States and 70 other countries. The coverage is worldwide, but most records are from English-language sources or have English abstracts. Although other databases and retrieval systems are available, such as for example Embase, Medline is generally considered the best source of evidence for health

Table 4. Topics investigated in Swedish publications in orthodontics during the period 1 January 1992 to 31 December 2002. Number and percent of each category of topic as well as distribution of number and percent between universities and clinics

Topic	Total	Universities	Clinics
Treatment	151 (51.9%)	97 (33.3%)	54 (18.6%)
Animal	27 (9.3%)	26 (9.0%)	1 (0.3%)
Material	16 (5.5%)	12 (4.1%)	4 (1.4%)
Development	54 (18.6%)	40 (13.8%)	14 (4.8%)
Diagnostic	31 (10.7%)	28 (9.7%)	3 (1.0%)
Services	9 (3.0%)	5 (1.7%)	4 (1.3%)
Education	3 (1.0%)	0 (0.0%)	3 (1.0%)
Total	291 (100.0%)	208 (71.5%)	83 (28.5%)

care, because of its depth, range, and continuous maintenance by the National Library of Medicine. Even though Medline contains some errors, it is generally accurate and extremely efficient as a subject-oriented retrieval tool (14, 15).

In an international perspective, Swedish dental research has a strong standing. It has been reported that Swedish scientists publish approximately 7% of all dental research papers included in databases and that the scientific impact of Swedish dental research is significantly above the average for the world in general (10). However, this systematic review showed that the Swedish contribution of research in orthodontics was not so prominent (1.9% of all orthodontic research papers). One reason could be tradition, since more focus and interest have been put on technical development or refinement of artistic talents than on scientific development and publications. Another reason could be that the major part of orthodontic research in Sweden was carried out at the 4 dental schools, and financial stress, reduction in budgets, and a stagnant turnover in staff in the 1990s may have affected the dental faculties and resulting in a lower number of publications. Furthermore, the majority of orthodontists are employed in the Public Dental Service (PDS), which does not remunerate research skills economically, or by advancements in position.

Quantitative assessment of the scientific merit of journals and articles has been used increasingly to assess and compare researchers and institutions. The most commonly used measure is the ISI Impact Factor, which broadly reflects the number of times each article in the journal has been cited over the previous 2 years. There are clear limitations to the use of such measures, e.g. IFs reflect the journal not the article and vary with time. Moreover, simple comparison of IFs in different specialties may be misleading. Review journals often have higher IFs than those with original data. However, despite valid concerns, IFs are widely used and offer, at present, the best simple tool for comparison of output. Like all measures, the use of IFs has to be tempered with knowledge of their limitations and common sense used in interpreting any data based on any analysis (16, 17). This review showed that most Swedish authors preferred to publish their articles in orthodontic and non-orthodontic journals with an IF. It was also found that many high-quality studies with orthodontic interest (34%) were published in non-orthodontic journals with higher IF scores than the orthodontic journals, and this raises the question of whether these articles are more or less out of reach for orthodontists who are not in academics. The criteria used by authors to select journals for manuscript submission have been investigated previously (18). Journal prestige, previous publications of papers on the same topic, and composition of the readership were the most frequently cited reasons for the initial choice of journal. For subsequent submissions, the likelihood of having the manuscript accepted was acknowledged to be the most important factor. This suggests that prestige-related criteria are paramount for initial submissions, but more pragmatic reasons dominate in subsequent submissions. One conceivable reason why for example the *Swedish Dental Journal* was relatively often preferred may be that almost all Swedish dentists subscribe to the *Swedish Dental Journal*, and thus that a paper in this journal will be read by most Swedish colleagues. Moreover, interceptive treatments with removable appliances, which comprise between 10% and 20% of all orthodontic treatments in Sweden (19), are carried out by general dentists.

To conduct prospective, controlled, clinical studies, it is necessary to have access to a patient material that is unselected, and those patients are more easily selected in the PDS than at universities. Therapeutic interventions of patients and developmental studies of untreated humans were the 2 most frequent topics, and those topics were also the most common among studies performed at the universities and at the clinics. This may reflect that the orthodontic services of the PDS and the research programs at the orthodontic departments in university dental faculties in Sweden are well integrated. Moreover, the specialist training programs are well established and integrated with the research programs at the orthodontic departments. Thus, in the Swedish system it is easy for clinical investigators to obtain research material comprising both treated and untreated subjects. In light of the general interest in the past decade in discussions on toxicity among citizens in Sweden and throughout Europe, it was surprising that only few studies involved materials science ($n = 16$). Also, few animal and cellular biology studies had been performed ($n = 27$). This may mirror the prevailing concern in Sweden about animal experiments, which must undergo rigorous ethical conditions to be approved, and which have been the topic of much debate in the past 10 to 15 years.

Analysis of the Swedish research papers on the effectiveness of orthodontic treatment confirmed the impression that most of the present evidence is derived from prospective and retrospective studies with very little data from RCTs. A randomized clinical trial is our most powerful tool for evaluating therapy, and the quality of the trial significantly impacts the validity of the inferences (20). Although it may not be possible to conduct RCTs to investigate all aspects of clinical orthodontics, most studies that compare appliances, materials, or treatment strategies could be conducted in this way. RCTs have rarely been used in orthodontics (2), and one reason might be the practical difficulty of gathering enough patients for the trial. In this review, it was found that 5.2% of Swedish orthodontic papers were RCTs; this figure can be compared with the findings of Sjögren & Halling (9), who reported that 5% of all dental research between 1966 and 1999 were RCTs. Another finding of this review was that control groups were often not used. It is has been stressed that well-conducted studies with internal controls (comparison groups that are enrolled and followed simultaneously with the experimental groups) will support substantially stronger inferences than studies with external controls (21).

In classifying articles according to the research design it can often be difficult to interpret whether a study is prospective or retrospective. To diminish the confusion about this, two independent reviewers in this study categorized the articles according to research design, and if inter-examiner disagreements existed, consensus was reached by discussion.

In conclusion, a total of 15,572 articles in orthodontic research have been published during the past decade, and the Swedish contribution was 1.9%. Most of the Swedish articles (84.5%) were published in 10 journals; 56.4% in orthodontic journals and 43.6% in non-orthodontic journals. It was also found that many high-quality studies with orthodontic interest (34%) were published in non-orthodontic journals with higher IF scores than the orthodontic journals, and this raises the question of whether these articles are out of reach for orthodontists who are not in academics.

The majority of the articles evaluated therapeutic interventions, and although the RCT is the preferred design for such interventions, only 5.2% of all articles ($n = 15$) used this method. Despite an increased familiarity with more powerful methods of obtaining information, orthodontic researchers in Sweden have been slow to adopt such methods. The validity of the information reported in the literature and the applicability of the conclusions and inferences that can be drawn are likely to become even more important in an era increasingly focused on evidence-based medicine, and for which the specialty's shortcomings are increasingly coming under attack. To employ the RCT design in forthcoming studies is the particular challenge of Swedish orthodontists today.

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