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POST-OPERATIVE PAIN: AN ANALYSIS ON EVOLUTION OF RESEARCH IN HALF-CENTURY

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Introduction

Every year, millions of teeth around the world are saved by root canal treatments. According to an American Dental Association survey, approximately 15.1 million patients received root canal treatments in the United States (1). Pain after root canal treatment is a major health problem affecting the quality of life in the short-term and sometimes also in the long-term. Root canal treatment is generally very effective in alleviating tooth pain (2, 3). However, recent prospective studies indicate that severe pain can occur in approximately 20% of patients during the week following root canal treatment (4). In other words, one out of every five patients who receive root treatment will experience a major disruption in their daily life due to this unwanted postoperative outcome. Further, up to 10% of patients may suffer from persistent pain 6 months after endodontic treatment (5). Overall, these numbers show that millions of patients in the United States and, by inference, around the world deal with severe pain in the days following root canal treatment, and many develop persistent pain. Post-operative pain can significantly affect quality of life (6) and lead to serious economic consequences. This includes the impact on the patients' daily performance (physical and emotional impacts of pain) (7), and increases spending by patients, insurance companies, and governments on medications and additional dental/medical visits.

As researchers understand the mechanisms and predictors of pain after root canal treatment, they find more relevant ideas about how to address this health problem. In addition, technologic advances in treatment and research methods can encourage new research. Therefore, the variables of interest in research studies change over time. Also, researchers revise the methodologies adopted for investigations as they learn more about evidence-based medicine The aim of this study was to analyze the evolution of study design and research variables in the field of post-operative pain over the past 50 years.

MATERIALS AND METHODS:

Search strategy The study protocol was developed by the authors in October 2019. In December 2019, electronic searches were conducted in Scopus and MEDLINE (via PubMed search engine) databases. The optimized search strategy in Scopus was "pain [AND] endodonti*"; and in MEDLINE it was "pain [AND] endodontic." The language was limited to "English" in both databases. No other limitation was set. Study selection Two authors (AN and OD) independently reviewed titles and abstracts of all publications identified in the database searches. Articles related to pain after non-surgical root canal treatment/retreatment of permanent teeth were included. Articles related to pain after surgical endodontic

procedures, pulpotomy, or endodontic procedures on primary teeth, and articles without an available abstract were excluded. The resulting lists of papers were cross-checked, and disagreements resolved by reviewing the inclusion/exclusion criteria. The final list of papers was exported as a .CSV file and was subjected to the following analyses. Data extraction and descriptive analyses.

The study design was determined for each paper, as described previously (8, 9). The categories were: systematic review, clinical trial, prospective cohort, retrospective cohort, cross-sectional study, case series/case report, and review/expert opinion.

The clinical studies were subjected to full-text review and the following variables were extracted: sample size; duration of follow up; number of treatment visits; pulpal diagnosis; periapical diagnosis; tooth type; pain scale(s) used for assessments; provider type; and patients' demographics. The independent variables in clinical trials were determined and categorized into the following: pre-operative pain, adjunct treatment, instrumentation, irrigation, obturation, medication/medicament, and number of visits.

The frequency and proportional distribution of studies based on the variable of interest and decade of publication were determined and descriptively analyzed.

Statistical analyses

A trend analysis was performed on publications after their distribution based on variable of interest was determined per decade. A "trend" is a meaningful upwards (positive) or downwards (negative) shift in data overtime. "Trend analysis" quantifies and explains trends and patterns in "noisy" data over time. Two statistical methods were utilized for this purpose: A) Chi-squared test statistic for Pearson's Correlation coefficient between the variable and the variable's average time ranks to determine if there is a "statistically meaningful" trend; and B) Variance-weighted least-squares regression method to examine if the trend is linear or non-linear. When these analyses showed a trend (positive or negative; linear or non-linear), Chi-square tests were performed for decade-decade comparisons to determine the two decades between which the trend existed. d. The significance level was set at <0.05. The analyses were done using STATA 16.

RESULTS

The electronic search resulted in 2,289 publications in Scopus and 2,050 publications in MEDLINE. After removal of duplicates and screening titles and abstracts, 424 articles were selected.

The number of publications per decade varied from 2 in 1970-79 to 274 in 2010-19. The distribution of articles based on study design in each decade is shown in Figure-1. Clinical trials (randomized/non-randomized) constituted the highest proportion of articles in every decade. However, there was no meaningful trend towards publishing clinical trials (P=0.56). There was a negative trend in the publication of retrospective cohort studies in 2000-2019 (P=0.01). There was a positive trend for publication of systematic reviews between 2000-2019 (P=0.006), with them being published only in the past two decades.

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Clinical studies comprise clinical trials, cohort studies, and cross-sectional studies which constituted a pool of 327 articles. In this pool we excluded 5 cross sectional studies because they were questionnaires sent to the clinicians, not the patients. The final sample size for clinical studies was 322.

Clinical studies were categorized into four groups based on their sample size: 1-199; 200-499; 500-999; ≥1,000. Distribution of clinical studies based their sample size and decade of publication is shown in Figure-2 (Left). Studies with sample size of ≥1,000 formed the smallest fraction of the clinical studies in each decade (Fig. 2, Left). A total of eleven clinical studies (3.4%) with sample size >1,000 were published (10-20). There was a positive trend for studies with sample size of<200 between 2000-2019 (P=10-20). There was a negative trend for studies with sample size of 200-499 between 2000-2019 (P=0.02).

Clinical studies were categorized into five groups based on the period of observation: ≤2 weeks, >2-8 weeks, >8 weeks – 12 months. Distribution of clinical studies based on period of observation is illustrated in Figure-2 (Right). Studies with follow-up period of ≤2 weeks were the most common in all decades. Studies with follow-up ≥6 months which were aimed to detect chronic pain after treatment were rare (n=8; 2.4%) (Fig. 2, Right). Studies with follow up of >12 months were performed only in 2010-19. An observation period could not be determined in 43 (13%) studies. Studies with observation period of 2-8 weeks showed a negative trend between 2000-2019 (P=0.04). Other categories showed no trend (P>0.05).

The total number of studies on single visit treatment was close to those on multiple visit treatments (106 and 117 studies, respectively). In 58 studies (18%) the treatments were mix of single visit and multiple visits. Number of visits could not be determined in 41 (13%) studies. There was a positive trend for studies on single-visit treatment (P=0.0002) and a negative trend for studies on multiple-visit treatment (P=0.001) between 2000-2019 (Fig. 3, Left).

The pain scales were categorized into 3 main groups: visual analogue scale (VAS; including the variation of Heft-Parker), numerical rating scale (NRS; also includes graded chronic pain scale or GCPS, and Likert-10), and McGill. Some studies used more than one scale to measure the pain intensity, while the type of pain scale could not be determined in 59 (18%) studies. VAS has been the most common scale used since 80s (n=174; 54%). There was a negative trend for using NRS between 2000-2019 (P=0.04) (Fig. 3, Right).

Pulpal diagnoses were categorized into non-vital (pulp necrosis), vital (normal pulp; symptomatic/asymptomatic irreversible pulpitis), and previously treated. Most studies were done on primary root canal treatments (non-vital and/or vital teeth) (n=252; 78%). Previously treated teeth were the least studied group (n=18; 5%) (Fig. 4, Left). Pulpal diagnosis could not be determined in 43 (13%) studies. The publications showed no trend regarding the pulpal diagnosis (P>0.05).

Data regarding tooth type was properly presented in 113 (35%) studies. Some studies included more than one tooth type. Among all teeth included in the studies, mandibular molars were the most studied group, followed by maxillary molars. Mandibular incisors were

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the least studied group. There was a negative trend for publications on maxillary incisors between 1990-2010 (P=0.01) (Fig. 4, Right).

A summary of independent variables tested in clinical trials are presented in Box-1. There was a positive trend for clinical trials on instrumentation (P=0.000) as well as adjunct treatments (P=0.01) between 2000-2019. There was a negative trend for clinical trials on medication/medicament between 2000-2019 (P=0.03) (Fig. 5).

Data regarding periapical diagnosis, type of operator and patients' demographics could not be analyzed. The periapical diagnosis was presented in only 28% of the studies. The terminology used for periapical diagnosis was also inconsistent. The patient's demographics (age and gender) and the type of operator were properly presented in only 20% of the articles.

FIGURE LEGENDS:

Figure-1: Proportional and frequency distribution of all 424 publications based on study category and decade of publication. Black asterisk shows positive trend compared to the previous decade. Red asterisk shows negative trend compared to the previous decade.

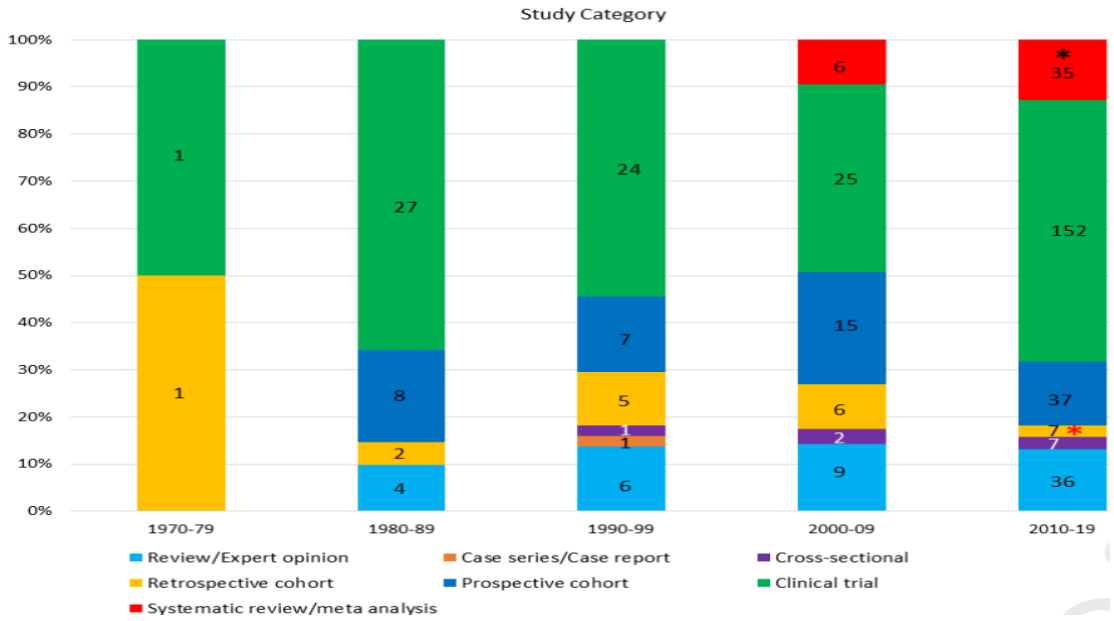

Figure-2: Proportional and frequency distribution of clinical studies based on: Left- sample size and decade of publication. Right- Observation period and decade of publication. Black asterisk shows positive trend compared to the previous decade. Red asterisk shows negative trend compared to the previous decade. W= week, m=month.

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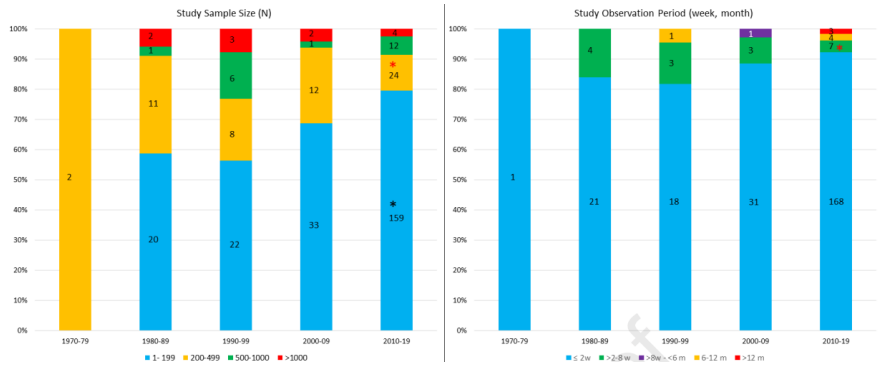

Figure-3: Proportional and frequency distribution of clinical studies based on: Left- Number of visits and decade of publication. Right- Pain scale and decade of publication. Black asterisk shows positive trend compared to the previous decade. Red asterisk shows negative trend compared to the previous decade. VAS: visual analogue scale; NRS: numeric rating system.

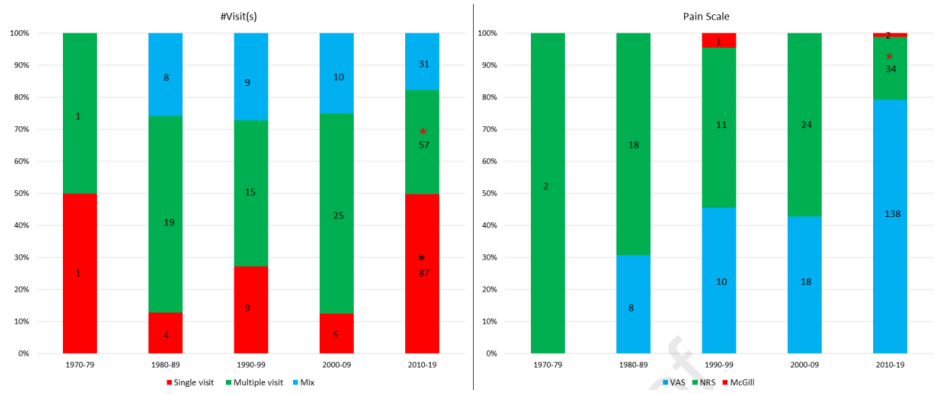

Figure-4: Proportional and frequency distribution of clinical studies based on: Left- Pulpal diagnosis and decade of publication; Right- Tooth type and decade of publication. Red asterisk shows negative trend compared to the previous decade. No statistically meaningful trend was found for distribution of publications based on pulpal diagnosis. Dx: diagnosis; Mand: mandibular; Max: maxillary; Prem: premolar; Incs: incisor.

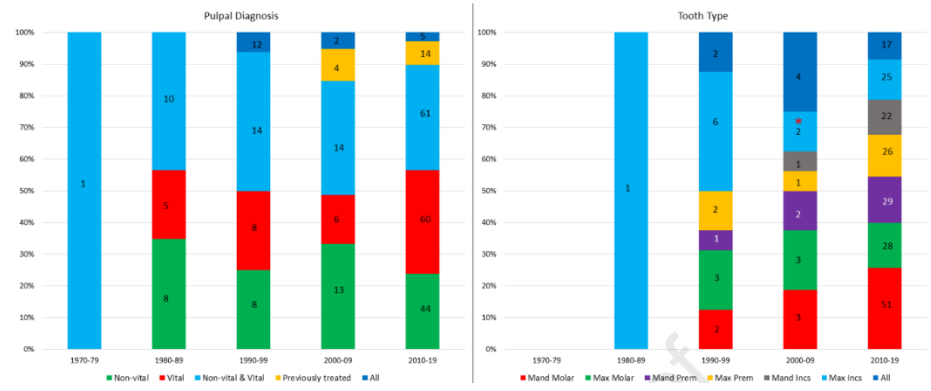

Figure-5: Proportional and frequency distribution of clinical trials based on the independent variable and decade of publication. Black asterisk shows positive trend compared to the previous decade. Red asterisk shows negative trend compared to the previous decade. Tx: treatment.

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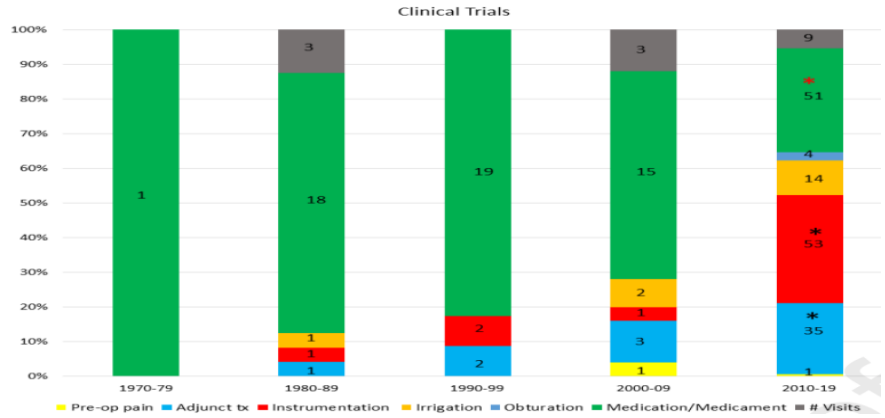

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