Trabalho de Conclusão de Curso

Taxas de Sucesso do Tratamento Endodôntico: uma Revisão Sistemática e Meta-Análise

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Trabalho apresentado à Universidade Federal de Santa Catarina, como requisito para a conclusão do Curso de Graduação em Odontologia.
Orientador: Prof.ª Dr.ª Dayane Machado Ribeiro.

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Maria Eduarda Póvoas de Carvalho

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UMA REVISÃO SISTEMÁTICA E META-ANÁLISE**

Este Trabalho de Conclusão de Curso foi julgado, adequado para obtenção do título de cirurgião-dentista e aprovado em sua forma final pelo Departamento de Odontologia da Universidade Federal de Santa Catarina.

Florianópolis, 22 de Maio de 2018.

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Dedico este trabalho às pessoas que amo e que estiveram comigo nesta trajetória.

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“Success is a journey, not a destination. The doing is often more important than the outcome.”

(Arthur Ashe)

APRESENTAÇÃO

Esta revisão sistemática foi originalmente escrita na forma de artigo na língua inglesa para ser submetida ao periódico *International Endodontic Journal*, em parceria com pesquisadores da Universidade Federal de Santa Catarina (UFSC) Prof.ª Dr.ª Dayane Machado Ribeiro, Prof.ª Dr.ª Graziela De Luca Canto, Prof. Dr. André Luís Porporatti, Prof.ª Dr.ª Kamile Leonardi Dutra Horstmann e Jéssica Conti Réus; a pesquisadora da Universidade de Detroit Mercy (Estados Unidos) Prof.ª Dr.ª Ana Cristina Caldeira de Andrada; e a pesquisadora da Universidade de Alberta (Canadá) Prof.ª Dr.ª Camila Pacheco.

RESUMO

Objetivo: O principal objetivo do tratamento endodôntico é prevenir ou tratar patologias periapicais, que ocorrem devido a infecção do canal radicular, subsequente a cáries, tratamentos cirúrgicos e/ou trauma. Neste sentido, esta revisão sistemática visa analisar as taxas de sucesso, fatores que podem estar afetando o resultado e se os profissionais estão alcançando a meta deste tratamento, que é saúde dos tecidos periapicais. O foco deste artigo é centrado em responder a seguinte questão: Qual a taxa de sucesso do tratamento endodôntico inicial em dentes permanentes? **Métodos:** Dois revisores pesquisaram em quatro bases de dados principais (PubMed, LILACS, Web of Science and Scopus) e três bases de literatura cinzenta (Google Scholar, ProQuest e OpenGrey). Os artigos foram coletados com base nos critérios predeterminados: estudos que avaliem o sucesso do tratamento de canal, feito em dentes permanentes, realizado por profissionais da odontologia, e as imagens radiográficas devem ser avaliadas pelo periapical index (PAI). Não foram feitas restrições quanto ao ano da publicação e os idiomas poderiam ser Inglês, Espanhol ou Português. Avaliação da Graduação de Recomendações e Desenvolvimento (GRADE) avaliou a qualidade de evidência do artigo. MAStARI avaliou a qualidade metodológica dos artigos. **Resultados:** Dos 1523 artigos, 20 preencheram os critérios de inclusão para a análise qualitativa. Um deles teve um alto risco de viés, 7 tiveram moderado risco e 12 tiveram baixo risco de viés, de acordo com o checklist do MAStARI. A meta-análise foi conduzida com 18 estudos, com o programa MedCalc Statistical Software versão 14.8.1. Foi feito um grupo com as taxas de sucesso geral e 5 subgrupos foram feitos: tipo de estudo, tipo de radiografia, tempo de acompanhamento, tipo de instrumentação e número de visitas. As taxas de sucesso do tratamento endodôntico inicial, realizado por cirurgiões dentistas foi de 78,56%. **Conclusão:** Dentro das limitações

dos estudos incluídos e das baixas evidências encontradas, as taxas de sucesso do tratamento endodôntico inicial, realizado por cirurgiões dentistas foi alta (78,56%). Nossos resultados comprovam que 'tempo de acompanhamento', tipo de instrumentação' e 'número de visitas (única ou duas visitas)' não teve influência no resultado final. Por esta razão, o profissional deve ser capaz de avaliar o método mais apropiado, de acordo com sua habilidade, experiência e o diagnóstico do paciente, para fornecer o melhor tratamento e alcançar estas taxas de resultados.

Palavras-chave: tratamento de canal, tratamento endodôntico, resultado endodontia, sucesso, revisão sistemática.

ABSTRACT

Background: The main goal of endodontic treatment is either to prevent or treat periapical pathologies, that occurs due to infection of root canal system, subsequent to tooth caries, surgical treatments and/or trauma. In this sense, this systematic review intended to analyze the success rates, factors that could be affecting the outcome and if professionals are achieving the purpose of RCT that is periapical health. The focus of this paper centered was answering the following question: What is the success rate of primary root canal treatment in permanent teeth? **Methods:** Two reviews searched in four main databases (PubMed, LILACS, Web of Science, and Scopus) and three grey literature databases (Google Scholar, ProQuest, and OpenGrey). The articles were collected based on predetermined criteria: studies that assessed the success of root canal treatment in human permanent teeth, performed by dentistry professionals, and radiographic images evaluated by the periapical index (PAI). No restrictions regarding year of publication were applied and search comprised studies in English, Spanish, and Portuguese languages. The meta-analysis was conducted in studies that assessed the overall success rates, with the aid of MedCalc Statistical Software version 14.8.1. Also, the quantitative analysis assessed five subgroups according to type of study, type of radiography, time of follow up, type of instrumentation technique and number of visits (single or two-visits). GRADE-tool assessed the quality of the evidence. MAStARI evaluated the methodological quality. **Results:** From 1523 articles, 20 met the inclusion criteria for a qualitative analysis. One of them had a high risk of bias (RoB), 7 had a moderate RoB, and 12 had a low RoB scored according to the MAStARI checklist. The success rates of primary root canal treatment was 78,56%. Time of follow up, instrumentation technique and number of visits do not have influence on RCT final outcome. **Conclusion:** Within

the limitations of the included studies and the very low evidence found, it should be concluded that the success rates of primary RCT in human permanent teeth, performed by dentist was high (78,56%). Time of follow up, instrumentation technique and number of visits do not have influence on RCT final outcome. For this reason, the professional should be able to evaluate the most appropriate method according to their ability, experience and patient's diagnostics to provide the best treatment and achieve these outcome rates.

Keywords: root canal treatment, endodontic treatment, endodontic outcome, success, systematic review.

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LISTA DE ABREVIATURAS E SIGLAS

Do inglês

RCT	*Root canal treatment*
RF	*Root fillings*
PAI	*Periapical Index*
CBCT	*Cone Beam Computed Tomography*
RoB	*Risk of Bias*
CI	*Confidence Interval*
SoF	*Summary of Findings*
PRISMA	*Preferred Reporting Items for Systematic Reviews and Meta-Analyses*
GRADE	*Grading of Recommendations Assessment, Development and Evaluation*

SUMÁRIO

1 INTRODUÇÃO

Infecção dos canais radiculares ocorre após cárie dentária, tratamentos cirúrgicos e/ou trauma dental. Devido à estreita relação entre a polpa dentária e os tecidos periapicais, a passagem de bactérias e outros microorganismos através do canal radicular é permitida, iniciando um processo inflamatório, que pode levar a formação de abscesso, granuloma e cisto periapical (Moazami *et al.* 2011). O principal objetivo do tratamento endodôntico é prevenir ou tratar estas patologias periapicais (Tsesis *et al.* 2013). Este tratamento consiste na combinação de instrumentação mecânica do canal radicular, acompanhada de irrigação, debridamento químico e preenchimento com um material inerte, destinado a manter ou restaurar a saúde dos tecidos perirradiculares (Saini *et al.* 2012).

A manutenção da integridade, estética e função do arco é o que a maioria dos pacientes desejam (Fleming *et al.* 2010). Existem estudos publicados sobre o sucesso do tratamento endodôntico. Alguns deles consideram o sucesso baseado apenas na cicatrização radiográfica, enquanto outros consideram o dente presente e funcional na cavidade oral. Dependendo do ponto de vista do observador, existem diferentes maneiras de definir o "sucesso" do tratamento.

De acordo com Ng *et al.*, pesquisadores estão interessados em identificar fatores prognósticos, por isso tendem a optar por sinais radiográficos e clínicos de resolução da doença periapical. Do ponto de vista do paciente, a resolução dos sintomas e a funcionalidade do dente correspondem ao sucesso. Da perspectiva do seguro odontológico, a sobrevivência e retenção do dente em boca é um resultado interessante e esperado. Procedimentos de tratamento do canal radicular tem sido avaliados por sinais e sintomas de cicatrização periapical, mas tratamentos alternativos, como implantes, focam na sobrevivência do dispositivo osseointegrado (Ng *et al.* 2011).

Em 1986, Osrtavik *et al.* apresentou um sistema de pontuação, chamado de Periapical Index (PAI). Este índice foi criado para avaliar o estado periapical em radiografias intra-orais, com a intenção de ser usado em estudos epidemiológicos, ensaios clínicos e análises retrospectivas de resultados de tratamentos endodônticos. O PAI consiste em cinco categorias - o número 1 sendo estruturas periapicais normais e o número 5 como periodontite grave, com características exacerbantes e expansão óssea (Figura 1). Além disto, este índice fornece critérios confiáveis e reprodutíveis (Orstavik *et al.* 1986, Dolci *et al.* 2016).

Preenchimento incompleto do canal, perfurações do canal, canais radiculares perdidos ou não preenchidos são algumas das causas mais frequentes de falhas no tratamento endodôntico inicial (Monea *et al.* 2015). Entretanto, os resultados também podem ser influenciados por fatores que não podem ser controlados pelo profissional. Por exemplo, muitos estudos utilizam como critério de exclusão pacientes que possuem algumas condições sistêmicas, como diabetes mellitus (Trope *et al.* 1999, Peters *et al.* 2004, Penesis *et al.* 2008, Fleming *et al.* 2010, Paredes-Vieyra *et al.* 2012, Saini *et al.* 2012, Rodney V. Scott 2013, Chisnoiu *et al.* 2016). Artigos recentes sugerem que pacientes diabéticos podem ter resultados mais desfavoráveis em dentes com periodontite apical. Embora existam estudos demonstrando que fumantes também apresentam cicatrização tardia, a maioria deles não excluem estes pacientes (Doyle *et al.* 2007).

Uma revisão sistemática (Ribeiro *et al.* 2017) sobre a qualidade técnica das obturações de canais realizadas por estudantes de graduação mostrou baixa frequencia de qualidade técnica aceitável. O conhecimento dos estudantes ou suas habilidades está diretamente ligado ao futuro dos procedimentos endodônticos e suas taxas de sucesso. Embora a qualidade dos tratamentos realizados pelos alunos não esteja tão alta quanto esperado, nesse sentido, o objetivo desta revisão sistemática é avaliar se os profissionais estão obtendo o sucesso adequado para o tratamento endodôntico,

apesar dos estudantes estarem falhando em fazê-lo. O foco deste artigo é responder a seguinte questão: Qual a taxa de sucesso do tratamento endodôntico inicial em dentes permanentes?

2 OBJETIVOS

2.1 OBJETIVO GERAL

Verificar qual a taxa de sucesso do tratamento endodôntico realizado em dentes permanentes.

2.2 OBJETIVOS ESPECÍFICOS

- Verificar se as taxas de sucesso estão relacionadas ao tipo de dente: anterior, pré-molar ou molar.
- Verificar o método de avaliação de imagem, entre radiografia periapical e tomografia computadorizada cone-beam.
- Verificar a diferença entre as taxas de sucesso de endodontistas e dentistas clínicos gerais.

3 CAPÍTULO 1

Success rates of primary root canal treatment: a systematic review and meta-analysis *

Category: Review
Running head: Outcomes

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INTRODUCTION

Infection of root canal system occurs subsequent to tooth caries, surgical treatments and/or trauma. Due to the close relation between of tooth pulp and periapical tissues, it allows passage of bacteria and other microorganisms through the root canal, initiating an inflammatory process which can leads to the formation of abscess, granuloma, and periapical cyst (Moazami *et al.* 2011). The main goal of endodontic treatment is either to prevent or treat these periapical pathologies (Tsesis *et al.* 2013). The treatment consists in a combination of mechanical instrumentation of root canal system, accompanied by irrigation, its chemical debridement and filling with an inert material designed to maintain or restore the health of periradicular tissues (Saini *et al.* 2012).

The maintenance of arch integrity, esthetics and function is what most patients ultimately desire (Fleming *et al.* 2010). There are published studies about the success of endodontic treatment, but some of them consider success based on radiographic healing alone, whereas others consider if it remains present and functioning in the oral cavity. Depending on the observer's point of view, there are different ways to define "success".

According to Ng *et al.* (2011), researchers are interested in identifying prognostic factors, so they tend to opt for radiographic and clinical signs of resolution of periapical disease. In patient's point of view, resolution of symptoms and tooth's functionality correspond to success. From dental insurance's perspective, survival and retention of tooth is an interesting outcome. Root canal treatment (RCT) procedures have been evaluated by signs and symptoms of periapical healing, but alternative treatments, such as implant retained

prostheses, focus on survival of the osseointegrated fixture (Ng *et al.* 2011).

In 1986, Orstavik *et al.* presented a scoring system, named the periapical index (PAI). This index was created to evaluate periapical status in intraoral radiographs, with the intention to be a useful tool for epidemiological studies, clinical trials and retrospective analyses of treatment results in endodontics. PAI consists of five categories - with number one being normal periapical structures to number five as severe periodontitis with exacerbating features and bone expansion - and provides criteria that are reliable and reproducible (Figure 1)(Orstavik *et al.* 1986, Dolci *et al.* 2016).

Incomplete filling, root perforations, missed, or unfilled root canals are some of the most frequent causes of primary endodontic treatment failures (Monea *et al.* 2015). However, the results may also be influenced by factors that cannot be controlled by the professional (Chisnoiu *et al.* 2016). For instance, many studies use as exclusion criteria patients with some medical conditions, such as diabetes mellitus (Trope *et al.* 1999, Peters *et al.* 2004, Penesis *et al.* 2008, Fleming *et al.* 2010, Paredes-Vieyra *et al.* 2012, Saini *et al.* 2012, Rodney V. Scott 2013, Chisnoiu *et al.* 2016). Recent reports suggest that diabetic patients may have poorer outcomes in teeth with preoperative apical periodontitis. Although there are studies demonstrating that smokers also present delayed healing, most of articles do not exclude these patients (Doyle *et al.* 2007).

A previous systematic review (Ribeiro *et al.* 2017) of technical quality of root fillings (RF) performed by undergraduate students has showed a low frequency of acceptable RF technical quality. The knowledge of

students or their skill-based are directly connected to the future of endodontic procedures and the success rates. Even though the quality of treatment performed by students is not as high as expected, it this sense, the aim of this systematic review was to address whether professionals are achieving proper treatment success (periapical healing) despite student's failure in doing so. The focus of this paper centered on answering the question: What is the success rate of primary root canal treatment in permanent teeth performed by dentists?

METHODS

This systematic review was reported according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The protocol was registered at the International Prospective Register of Systematic Reviews (PROSPERO) under number 73820 (PROSPERO, 2018).

Eligibility criteria

Inclusion criteria: studies that assessed the success of RCT in human permanent teeth performed by dentists were included. Success was evaluated by absence of periapical pathology based on radiographic images (periapical radiography or cone-beam computed tomography (CBCT)), absence of signs and symptoms and/or tooth retention. Radiographic images should have been evaluated by the periapical index (PAI), method created by Orstavik *et al.* (1986). No restrictions regarding year of publication were applied. Search comprised studies in English, Spanish, and Portuguese languages.

Exclusion criteria: 1) Literature reviews, case reports, letters, personal opinions, conference abstracts; 2) Studies including deciduous teeth or permanent teeth without complete root formation; 3) Studies performing endodontic retreatment; 4) Studies which root treatment was performed by dental students or undergraduate students; 5) Studies based on panoramic radiography; 6) Studies that did not use PAI as method of evaluation radiographic images; 7) In vitro and ex vivo studies; 8) Studies with duplicated data from previously included studies.

Information sources and search strategy

Individual search strategies for each bibliographic database were developed on PubMed, LILACS, Web

of Science, and Scopus. Additionally, grey literature searches on Google Scholar, OpenGrey, and Proquest were performed. The search was performed in July 4th, 2017 in each database by using specifics words combinations and truncations (see Figure 2). Hand-search of the references of all included articles was also accomplished. All references were managed on appropriate software (EndNote X7, Thomson Reuters) and duplicates were removed.

Study selection

The selection of included studies was completed in two phases, both performed by two reviewers. In phase-1, two reviewers (M.E.P.C. and J.C.R.) read and evaluated, independently, title and abstract of all studies, applying the eligibility criteria to define the studies included for phase-2. In phase-2, the same two reviewers (M.E.P.C. and J.C.R.) read the full-texts to confirm the eligibility of them. Any disagreement in both phases was resolved by means of discussion. If no consensus was achieved, a third author (D.R.M.) was contacted to bring resolution.

Data collection process

One author (M.E.P.C.) collected the main information from the selected studies. A second author (J.C.R.) crosschecked the collected information and confirmed its accuracy. Over again, any disagreement was resolved by discussion between the authors. The third reviewer (D.R.M.) was involved, when required, to make a final decision about the inclusion of articles.

Data items

The following data was recorded for each included article: author, year, country, study design, sample, type of teeth, instrumentation technique, professional training, type of radiograph, time of follow-up and

outcome. If the required data was incomplete, attempts were made to contact the authors to retrieve any missing information.

Risk of bias in individual studies

The risk of bias of selected studies was evaluated using the Meta-Analysis of Statistics Assessment and Review Instrument (MAStARI) critical appraisal tool (Joanna Briggs Institute, 2014). Two reviewers (M.E.P.C. and J.C.R.), independently, evaluated each domain in terms of the potential risk of bias. Different MAStARI questionnaires were used based on the included studies design (cross-sectional, descriptive studies, randomized controlled trial and quasi-experimental). Questionnaires consisted of questions with the possible answer of “yes”, “no”, “unclear”, or “not applicable”. Risk of bias was categorized by the authors as high when the study reached up to 49%, moderate when the study reached 50% to 69%, and low when the study reached more than 70% of “yes” scores. The authors crosschecked their evaluations and, in case of disagreement, a third author (D.M.R.) was involved to solve it.

Summary measures

The success rates of primary RCT in human permanent teeth, performed by dentists and assessed clinical and radiographically were analyzed, as well as the factors that affect the RCT outcomes.

The studies were evaluated radiographically by the Periapical Index (PAI), created by Orstavik (1986). In this scoring system, the scores 1 and 2 are considered good outcomes. PAI 1 was assigned to normal apical periodontium and PAI 2 to small changes in bone structure but not pathognomic.

Synthesis of results

Statistical pooling of data using meta-analysis was planned whenever trials were considered combinable and relatively homogeneous in relation to design, interventions and outcomes. Heterogeneity within studies was evaluated either by considering clinical, methodological and statistical characteristics, or using the inconsistency index (I^2) statistical test (Higgins and Green 2011). The success rates of RCT were analyzed by one type of meta-analyses, random effect model. Heterogeneity was calculated by I^2. Meta-analyses were performed with the aid of MedCalc Statistical Software version 14.8.1 (MedCalc Software, Ostend, Belgium). The significance level was set at 5%.

Confidence in cumulative evidence

A summary of the overall strength of evidence available was presented, divided by groups analyzed, using "Grading of Recommendations Assessment, Development and Evaluation" (GRADE). Summary of Findings (SoF) tables was produced with the aid of the GRADE online software (GRADEpro GTD, Copenhagen, Denmark), provided by the GRADE Working Group, in association with the Cochrane Collaboration and Members of McMaster University (Manheimer, 2012).

RESULTS

Study selection

In phase 1, 2.740 citations were identified from electronic databases. After removing the duplicated citations, the title and abstract of 1.523 articles were evaluated through the eligibility criteria. Therefore, 1.414 studies were excluded, resulting in a final number of 109 articles. Moreover, searches of grey literature were performed, adding 4 articles from Google Scholar, but none of them was selected for phase-2. No additional study was identified reviewing the reference list of all studies included. A total of 95 articles comprised phase 2. From these remaining studies, 75 were excluded (see reasons on Appendix B). Finally, 20 studies were selected for qualitative analysis. From these, 18 studies fulfilled the eligibility criteria and were adequate for quantitative meta-analyses. A flowchart summarizing this systematical selection process is shown in Figure 2.

Study characteristics

The included studies were conducted in twelve countries: Colombia (n=1), EUA (n=7), France (n=1), India (n=1), Iran (n=1), Israel (n=1), Italy (n=2), Lithuania (n=1), Mexico (n=1), Norway (n=1), Pakistan (n=1), and Romania (n=2). Sample sizes ranged from 22 (Chisnoiu *et al.* 2016) to 1960 teeth (Ramey *et al.* 2017). Ramey *et al.* had the biggest sample of the included studies, followed by Bernstein *et al.* (2012) with 1311 teeth and Tavares *et al.* (2009) with 1035 teeth in the sample. Of them all, Eriksen *et al.* (1995) was the one who had longer time of follow-up, with an average time of 20 years of follow-up, and Fernández *et al.* (2013) was the only one of the included that used CBCT to evaluate treatments. All included studies used

Periapical Index to registration of apical condition in radiographs.

From the 20 studies included in this review, thirteen were descriptive observational studies, four were quasi-experimental studies, two randomized controlled trials and only one was analytical cross-sectional study. A summary of the descriptive characteristics of the studies can be found in Table 1.

Risk of bias within studies

None of studies fulfilled all methodological quality criteria. One study had a high risk of bias (RoB), 7 had a moderate RoB and 12 had a low RoB scored according to the MAStARI checklist. Among all studies, Fleming *et al.* (2012) was the one with lowest risk of bias and Chisnoiu *et al.* (2016) was the one with highest risk of bias. Risk of bias was categorized as 'High' when the study reached a 'yes' score of up to 49%, which means that the study addressed specific points in their methodology. The RoB was considered 'Moderate' when the study reached a 'yes' score of 50-69% and 'Low' when the study reached a 'yes' score of more than 70%.

Furthermore, of all descriptive studies, 10 scored a low risk and 3 had a moderate risk of bias. In randomized controlled trials and quasi-experimental studies, also 3 had a moderate risk of bias, 2 had a low risk and just 1 had a high risk. The only cross-sectional study was Dolci *et al.* (2016), which scored a moderate risk of bias.

According to Cochrane (Cochrane Bias, 2018), bias is a systematic error or deviation from the truth, in results or inferences, which can lead to underestimation or overestimation of the true intervention effect. That is why risk of bias should be

examined, to increase the level of evidence of further studies.

In this study, the main topics that introduced bias to the studies were an insufficient description of who did the treatments, the variety of sample (teeth, patient and subjects) and confounding factors to deal with them not being described. Figure 3 presents detailed information on the RoB assessment.

Results of individual studies

The success rates of primary RCT, performed by dentistry professionals, ranged from 20,00% (Tsesis *et al.* 2013) to 96,95% (Fleming *et al.* 2010). Amongst all of the studies included, the success was evaluated radiographically by the PAI. Some of them, also evaluated clinical symptoms (Moazami *et al.* 2011, Chisnoiu *et al.* 2016, Paredes-Vieyra *et al.* 2012, Saini *et al.* 2012, Rodney V. Scott 2013, Bernstein *et al.* 2012), such as spontaneous pain, abscesses, mobility, sensitivity to percussion, and palpation.

Synthesis of results

A meta-analysis was conducted using 18 studies. For the meta-analyses purpose, two articles were excluded because their sample were stated as patient not reporting the teeth unit of analysis which unable to include their data in the meta-analysis (Ahmed *et al.* 2013, Saini *et al.* 2012).

The meta-analyses indicated high heterogeneity amongst studies ranging from 97,84% to 98,57%. The inconsistency was 98,21% and a random model was chosen. The main results were as follows:

- Overall success of primary RCT of permanent teeth, performed by dentistry professionals: 78,56% (95% CI 70,86 - 85,36; n=7.822) (Figure 4).

- In descriptive observational studies, overall success: 78,10% (95% CI 68,31 - 86,51; n=6.819); and in quasi-experimental, overall success rate: 80,71% (95% CI 58,70 - 95,59; n=367) (Figure 5 and 6).
- The success of periapical radiography was 76,07% (95% CI 65,98 - 84,87; n=4.918) and of digital radiography was 84,61% (95% CI 71,56 - 94,17; n=3.036) (Figure 7 and 8). Only one study evaluates CBCT and the success rate was of 81.30% in this method radiographic (Fernández *et al.* 2013).
- Evaluating the time of follow-up less than 2 years, the success rate was 79,33% (95% CI 63,10 - 91,77; n=1.485). Over than 2 years of follow-up was 78,75% (95% CI 62,41 - 91,37; n=2.488) (Figure 9 and 10).
- For manual instrumentation of root canal the success rate was 87,00% (95% CI 70,19 - 97,46; n=847) and for rotary system was 88,78% (95% CI 81,96 - 94,14; n= 1.235) (Figure 11 and 12).
- Treatment of one single visit had the success rate was 87,15% (95% CI 77,24 - 94,53; n=1.296). Treatments that required two visits the success rate was 81,33% (95% CI 66,53 - 92,54; n=1.573) (Figure 13 and 14).

RoB across studies

The main methodological limitations across the studies were related to sample. Some studies reported their sample as patient and others as teeth. To reduce the heterogeneity, in the present meta-analysis, only teeth were considered for quantitative analysis.

Other limitations were the professionals that conducted the treatment. Some of them were residents

of endodontic or endodontists with expertise in RCT, while others were general practice. The differences among dentist ability and knowledge could affect the treatment outcome.

Confidence in cumulative evidence

The overall quality of evidence identified using GRADE's SoF table was very low due to the following reasons: 1) observational studies started GRADE analysis from a low score, 2) high or moderate RoB scored for some studies (see Appendix 3), and 3) high I2 (inconsistency) scored by the meta-analysis for some studies (see in Figure 4 to Figure 14); suggesting very low confidence in the estimated effect from the assessed outcomes (Table 2).

DISCUSSION

The success rates of primary RCT, performed by dentists, in human permanent teeth were investigated in this meta-analysis and the results showed a high success rates (78,56%). This result was in accordance with previous systematic review, that reported success rates ranging between 68% and 85% (Ng *et al.* 2007). Also, our results were similar to the systematic review of Kojima *et al.* (2004), which presented a cumulative success rate of 82.80% for teeth with a vital pulp and 78.90% for non-vital teeth. The goal of our study was to analyze the success rates, as well as, the factors that could be affecting the RCT outcome.

Some of the potential clinical prognostic factors, such as professional training and tooth type, were heterogeneously reported by included studies enabling to run a meta-analysis on them. On the other hand, the following outcomes of 'time of follow-up', 'instrumentation technique' and 'number of visits that treatment required' were homogeneous reported by some of the included studies and enabled a meta-analysis into subgroups.

Based on the findings of this study and in accordance with Penesis *et al.* (2008) and Paredes-Vieyra *et al.* (2012), there was no significant differences between groups of one-visit and two-visits (87,15% and 81,33%, respectively). The first study used a paste made by mixing calcium hydroxide and chlorhexidine and the second one used a calcium hydroxide paste as intracanal medication. In this sense, Figini *et al.* (2008) made a systematic review about this theme and supports our findings that no detectable difference was found in the effectiveness of RCT in terms of radiologic success between single and multiple visits. Trope *et al.* (1999) also evaluated single vs. multivisit treatment and divided in 3 groups: one

appointment, two appointments but no intracanal medication and two appointments with calcium hydroxide paste for 1 week. The results revealed that the group of two visits and no calcium hydroxide were clearly inferior to the other treatment methods. Root canal cleaning and shaping effectively reduce microbiota in infected teeth, but not sufficiently to obtain complete antisepsis, therefore, intracanal dressing is indicated (Sharma *et al*. 2017). Currently, calcium hydroxide has been widely used in endodontic and is considered the first choice of root canal dressing materials, due to the variety of biological properties, such as antimicrobial activity, tissue-dissolving ability, inhibition of tooth resorption and hard tissue formation (Kim *et al.* 2014). Moreover, a systematic review (Sharma *et al.* 2017) was made about efficacy of calcium hydroxide against endodontic pathogens and concluded that the antimicrobial efficacy as a root canal dressing is similar for contact times between 7 and 45 days. It is important to emphasize that the application of intracanal medication is a big step to achieve success, eliminating any remaining bacteria after channel instrumentation, reducing inflammation of periapical tissues and pulp remnants (Chong *et al.* 1992).

The time of follow-up ranged from 4 months to 20 years. Most of the included studies, follow-up the treatments for 12 months and the success rate identified was 79,33%. Monea *et al.* (2015) concluded that adequate root fillings significantly reduced the presence of apical periodontitis, based on an evaluation of PAI scores which showed statistically significant differences between the scores recorded before and at 6-12 months control. Also, Pirani *et al.* (2015) supports that the 6-9 months evaluation appears to be an indicator for the final outcome of primary RCT, both in the presence or absence of initial

apical periodontitis. However, Ricucci *et al.* suggests that a diminished lesion diameter, radiographically, during the first 6-12 months after treatment is not automatically related to complete healing at longer follow-up (Ricucci *et al.* 2009). Although, there was no big difference in the results of meta-analysis comparing follow-up of 13 months and follow-up of over 2 years.

Currently, the use of rotary systems is making more popular in endodontic practice. There are many advantages of these systems, such as being more flexible and have superior resistance to torsional fracture as compared to stainless steel (Patil *et al*. 2017). Continuous improvements have been made to the instruments design with the implementation in the hope of achieving better and safe shaping with reduced risk of procedural accidents (Patil *et al*. 2017). It's known that the expenses for rotary system are bigger, since this method requires rotary files and motors. Furthermore, Gambarini *et al.* has shown a reduction in mechanical resistance of up to 50-60% between new and used NiTi rotary files after prolonged clinical use with high-torque endodontic motors. To reduce possible risks of intracanal breakage, clinicans should be aware that the reutilisation of NiTi rotary files dramatically affects their resistance to fatigue (Gambarini *et al.* 2001). Our findings showed that the success rates for this type of instrumentation was of 88,78%. For manual instrumentation, the success rate was also high (87,00%). Independently of the instrumentation technique, the principles and the goal are the same: provide a biological environment that is conducive to healing and provide a canal shape that is conformable to sealing (McSpadden, 2006). In 2016, Talebzadeh *et al*. made a prospective randomized controlled clinical trial to compare the effect of RCT with hand K-Flexofiles and rotary RaCe files on the incidence and intensity of postoperative endodontic

pain and the results showed that in both groups the severity of postoperative pain significantly decreased from the beginning to the end at all evaluated time intervals, with no statistically significant differences in pain severity (Talebzadeh *et al*. 2016). Moreover, professionals should take into account advantages and disadvantages of each method and also, the technical decision must consider clinical time and costs.

It is important to pointed out that this study has some limitations. For instance, each included study had their own way of classified success, based on clinical and/or radiographic criteria. One of the inclusion criteria of our study was that the radiography had to be evaluated by the Periapical Index. As reported in Wu *et al.* (2009), some authors considered PAI>2 as a successful index, while others still consider PAI>3 an acceptable index (Ørstavik *et al.* 1986, *Pirani et al.* 2015). PAI 2 and 3 represents a mild inflammation and changes in bone with some mineral loss, respectively. Ørstavik's *et al.* (2004) analyzed 192 roots that were treated with preoperative apical periodontitis. The results showed that when PAI scores of 1-2 were considered to represent successful outcomes, the success rate was 79% and when only teeth exhibiting a PAI score of 1 were considered to represent successful outcomes, the success rate dropped to 26%. Indeed, these variations of how classify success that can overestimate the outcomes (Ørstavik *et al.* 2004).

Additionally, the most used image method for success rate evaluation in the included studies was the periapical radiography. Which is a bi-dimensional evaluation of a tri-dimensional anatomical structure and therefore the results are not always exact. Nevertheless, these radiographs are most commonly used because of the low cost, greater accessibility to the patients and the smaller radiation dosage (Patel *et*

al. 2009). Only one included study used CBCT comparing to conventional and digital periapical radiography and reported a success rates of 94.30%, 92.30% and 81.30%, respectively (Fernández *et al.* 2013). Whereas, the results of our meta-analysis presented some different rates from the study cited above; for periapical radiography the success rate found was 76.07% and for digital radiography was 84.61%.

Another limitation of this systematic review was the fact that the professional training was not analyzed. At first, one goal of our study was to do a meta-analysis with these data, to discover if the increase of knowledge would increase the success rate. This was not possible due to lack of information on the articles. Many of them (Ahmed *et al.* 2013, Chisnoiu *et al.* 2016, Dolci *et al.* 2016, Eriksen *et al.* 1995, Paredes-Vieyra *et al.* 2012, Saini *et al.* 2012, Sidaravicius *et al.* 1999, Tavares *et al.* 2009, Trope *et al.* 1999, Tsesis *et al.* 2013) did not reported the dentist expertise level. Although previous studies shown that there is no significant difference in success rates carried out by undergraduates and professionals (Ingle *et al.* 1965, Cheung *et al.* 2002), it is a good topic to research about. In the latest systematic review of Ribeiro *et al.* (2017), the results revealed that the overall frequency of acceptable technical quality of root fillings performed by undergraduate students was low (48, 75%). In this sense, the success of the treatment encompasses the acceptable preparation and filling of canals, the exposure of preoperative radiographs, determination of the working length and radiological control of the filling (Er *et al.* 2006).

Such as level of professional specialization, it was also not possible evaluate if the success rates are related to tooth type (anterior, premolar and molar), due to lack of information. In this regard, a systematic

review (Ribeiro *et al.* 2017) has shown that the frequency of unacceptable root fillings increased as tooth position moved posteriorly. Presumably, the rates of successful treatments would increase with anterior teeth, owing to canal anatomy.

Moreover, in this study the sample was standardized and only sample of teeth were included for meta-analysis. For this reason, two studies are not in meta-analysis because the sample was patients (Saini *et al.* 2012, Ahmed *et al.* 2013). Despite that, one of these studies evaluated the effect of the apical preparation size on the outcome of endodontic treatment and concluded that there is statistically significant reduction in PAI scores. The proportion of successfully healed cases increased with an increase in the apical preparation size, improvements of 48% to 92% successful healing (Saini *et al.* 2012).

All over the world, tooth loss is still a serious public health problem and tooth retention throughout the life course should be the main concern for both dental surgeons in general and all professionals working in public health services. It will be a long journey and, certainly, more educational, preventive and also curative health measures must be taken in order to minimize distortions in the oral health of the populations of developing countries (Pedrazzi *et al.* 2008). Therefore, endodontic outcomes have been scientific interest for almost a century (Friedman *et al.* 2002), due to fact that the success rates of these treatments are a public health problem and the improvement of techniques and treatment objective could lead to a higher success rate (Cabral dos Santos *et al.* 2013). Higher survival rates were recorded for teeth with healthy periapical conditions, root canal fillings of the correct length, homogeneously condensed root canal fillings, root canal fillings in previously vital teeth, and teeth that had been

asymptomatic during treatment (Stoll *et al.* 2005). To conclude, public actions on oral health must bear in mind these success rates and invest in treatments that are for the government cheaper than the replacement of the teeth by dental prosthesis, more accessible to patients and less invasive for them.

CONCLUSION

Within the limitations of the included studies and the very low evidence found, it should be concluded that the success rates of primary RCT in human permanent teeth, performed by dentist was high (78,56%). Our results showed that 'time of follow up', 'type of instrumentation' and 'number of visits (single or two-visits)' do not have influence on the final outcome. For this reason, the professional should be able to evaluate the most appropriate method according to their ability, experience and patient's diagnostics to provide the best treatment and achieve these outcome rates.

CONFLICT OF INTEREST

The authors have stated explicitly that there are no conflicts of interest in connection with this article.

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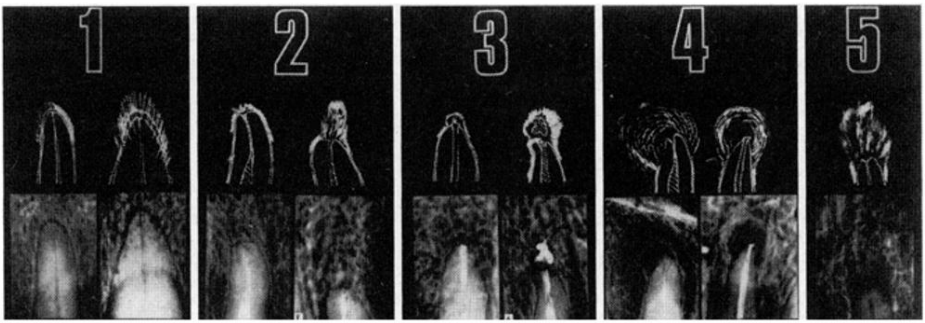
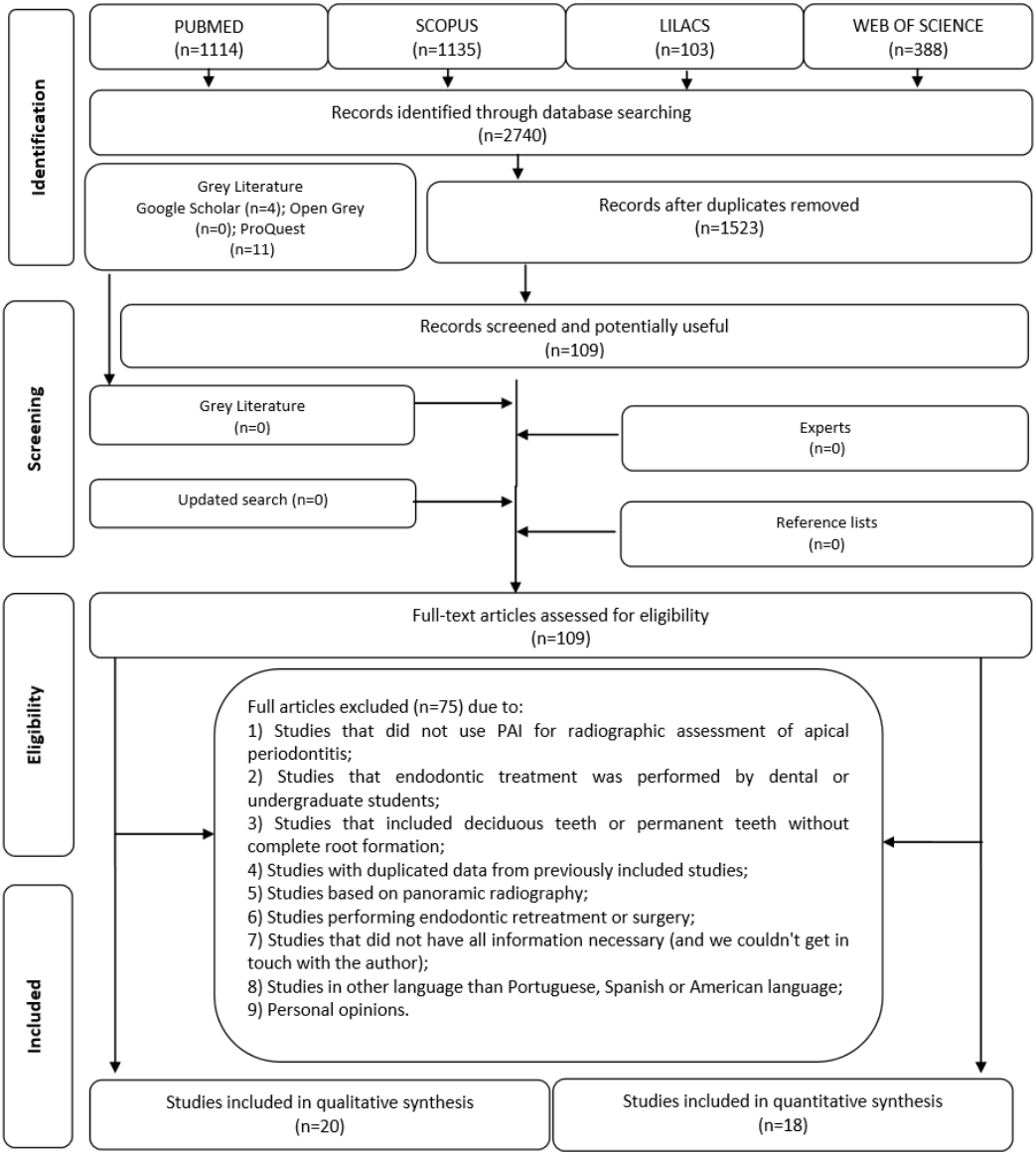
Figura 1. Periapical Index**.**



PAI Score	Description of radiographic findings
1	normal periapical structures
2	small changes in bone structure
3	changes in bone structure with some mineral loss
4	periodontitis with well-defined radiolucent area
5	severe periodontitis with exacerbating features

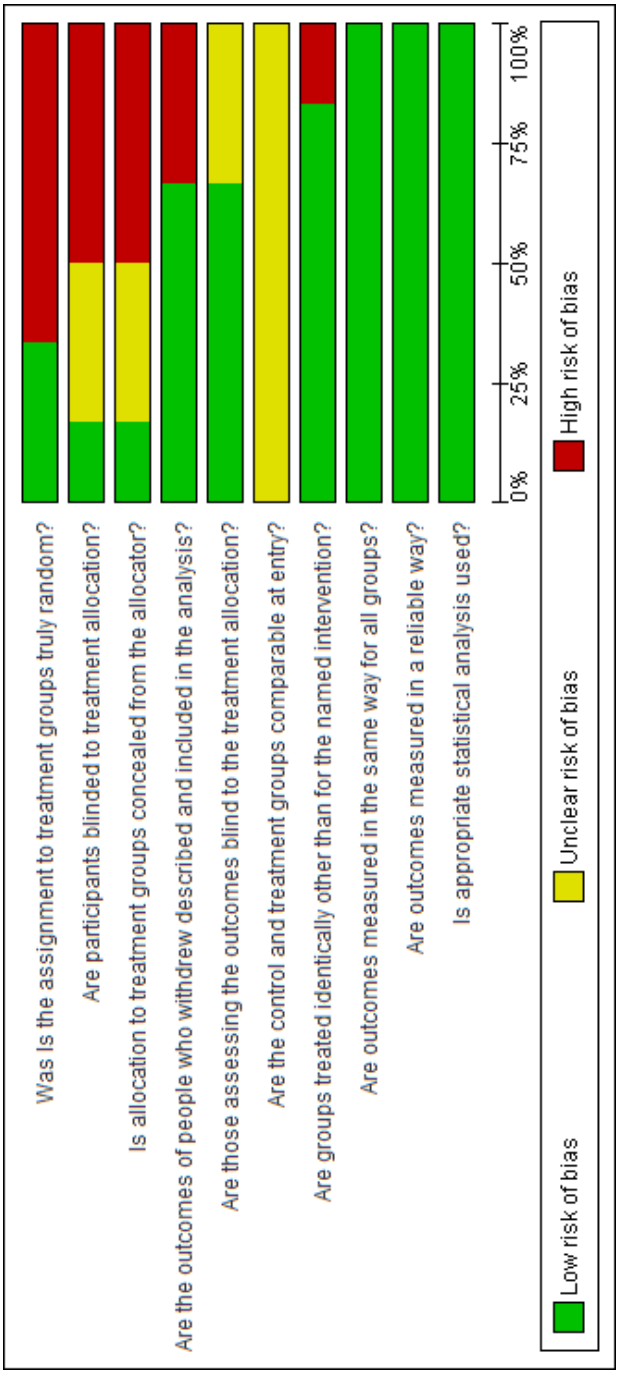
Adapted from Trope *et al.* (1999) and Penesis *et al.* (2008).

Figura 2. Flow Diagram of Literature Search and Selection Criteria.

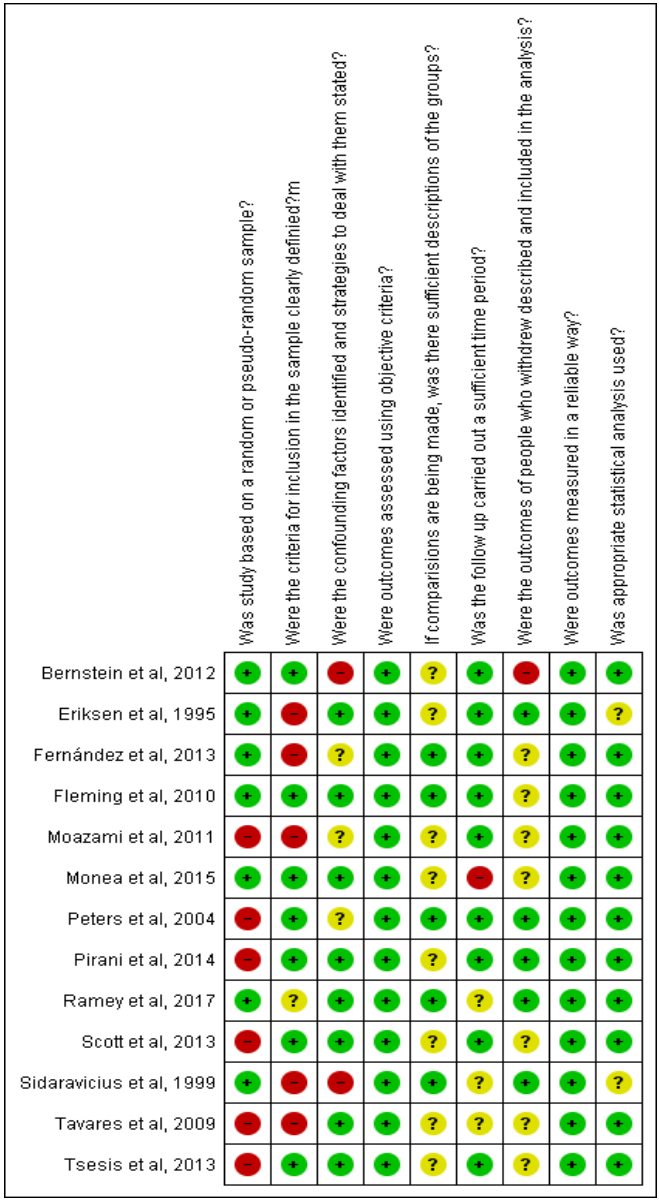


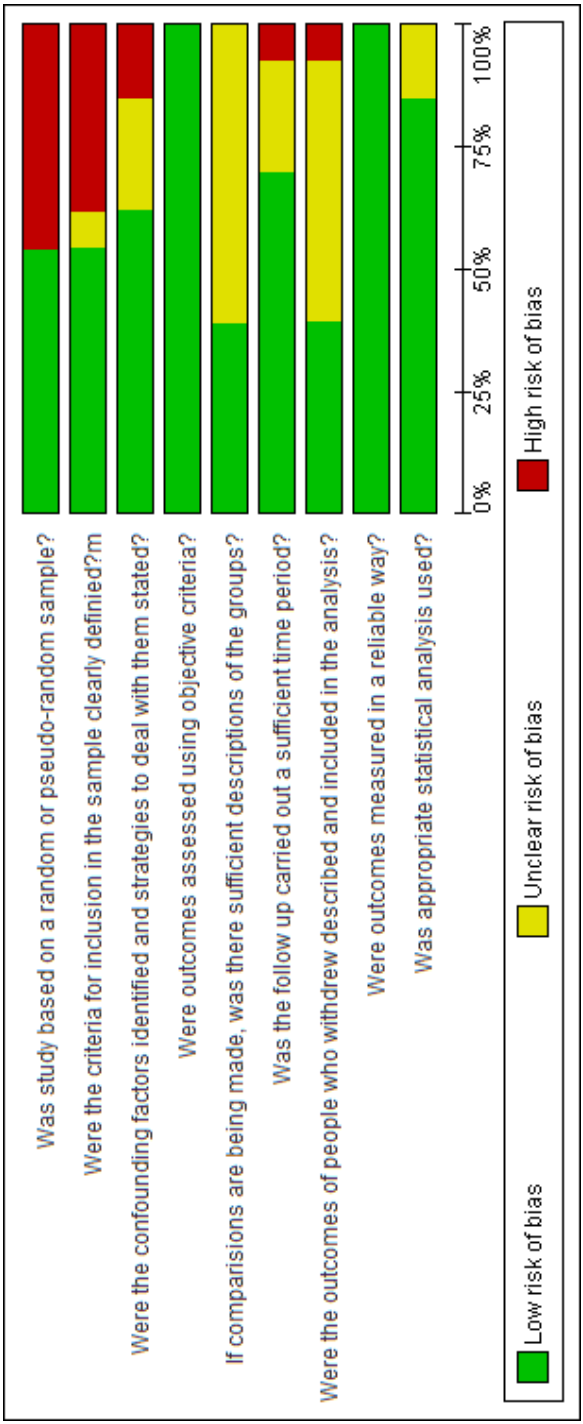
[1] Adapted from PRISMA.

Figura 3. Risk of Bias Summary.
Randomized Controlled Trial and Quasi-Experimental

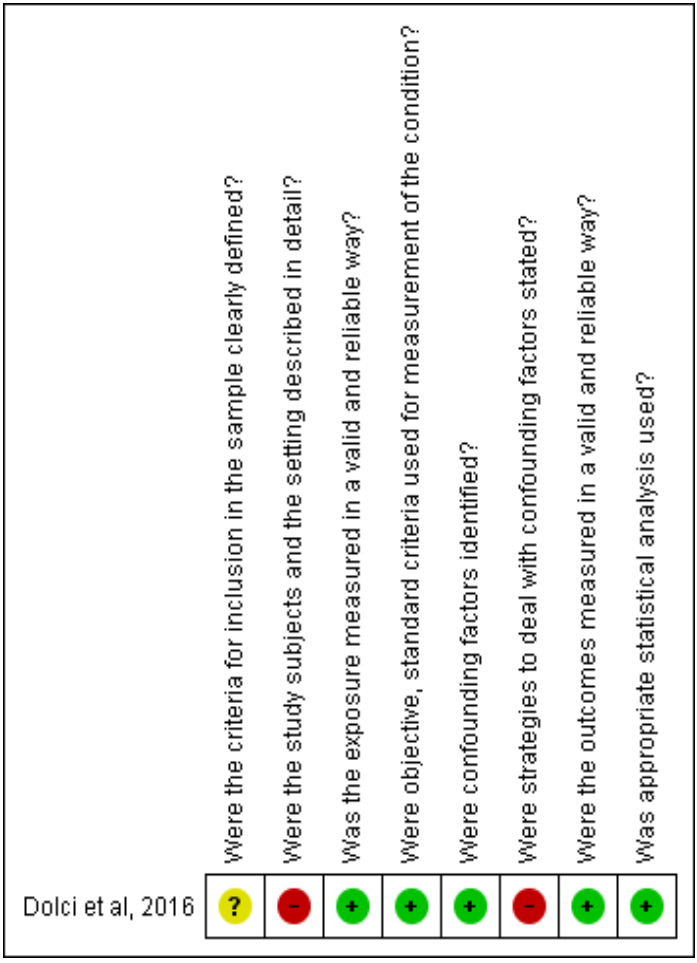

Was Is the assignment to treatment groups truly random?
Are participants blinded to treatment allocation?
Is allocation to treatment groups concealed from the allocator?
Are the outcomes of people who withdrew described and included in the analysis?
Are those assessing the outcomes blind to the treatment allocation?
Are the control and treatment groups comparable at entry?
Are groups treated identically other than for the named intervention?
Are outcomes measured in the same way for all groups?
Are outcomes measured in a reliable way?
Is appropriate statistical analysis used?
0%
25%
50%
75%
100%
Low risk of bias
Unclear risk of bias
High risk of bias

Descriptive Observational




Was study based on a random or pseudo-random sample?
Were the criteria for inclusion in the sample clearly definied?m
Were the confounding factors identified and strategies to deal with them stated?
Were outcomes assessed using objective criteria?
If comparisions are being made, was there sufficient descriptions of the groups?
Was the follow up carried out a sufficient time period?
Were the outcomes of people who withdrew described and included in the analysis?
Were outcomes measured in a reliable way?
Was appropriate statistical analysis used?
0%
25%
50%
75%
100%
Low risk of bias
Unclear risk of bias
High risk of bias

Analytical cross-sectional



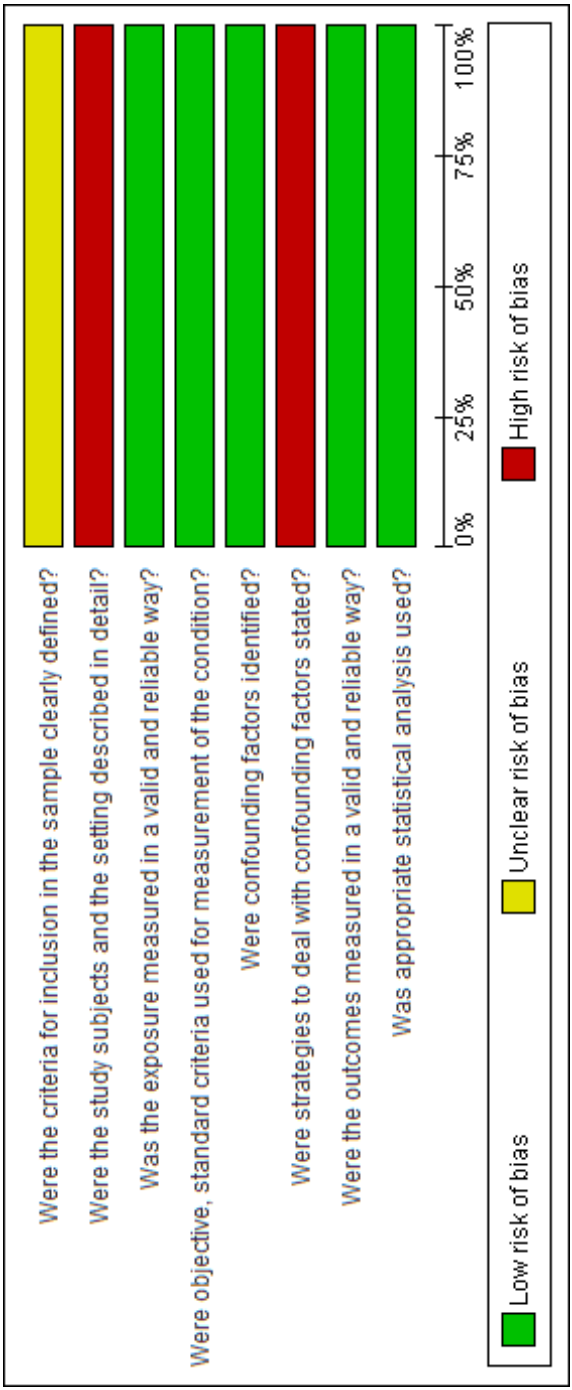

Were the criteria for inclusion in the sample clearly defined?
Were the study subjects and the setting described in detail?
Was the exposure measured in a valid and reliable way?
Were objective, standard criteria used for measurement of the condition?
Were confounding factors identified?
Were strategies to deal with confounding factors stated?
Were the outcomes measured in a valid and reliable way?
Was appropriate statistical analysis used?
0%
25%
50%
75%
100%
Low risk of bias
Unclear risk of bias
High risk of bias

Figura 4. Meta-Analysis (Success Rates; n=18).

Study	Sample size	Proportion (%)	95% CI
Dolci et al. (2016)	534	82,959	79,496 to 86,052
Monea et al. (2015)	71	70,423	58,407 to 80,670
Bernstein et al. (2012)	1311	80,854	78,618 to 82,951
Peters et al. (2004)	233	86,695	81,649 to 90,778
Pirani et al. (2014)	209	78,947	72,787 to 84,267
Ramey et al. (2017)	1960	89,082	87,617 to 90,429
Scott (2013)	188	71,809	64,800 to 78,115
Sidaravicius et al. (1999)	320	65,000	59,498 to 70,222
Tsesis et al. (2013)	200	20,000	14,689 to 26,223
Tavares et al. (2009)	1035	66,763	63,801 to 69,630
Fernández et al. (2013)	132	93,939	88,407 to 97,347
Fleming et al. (2010)	984	96,951	95,676 to 97,934
Moazami et al. (2011)	55	89,091	77,753 to 95,890
Eriksen et al. (1995)	121	84,298	76,570 to 90,273
Paredes-Vieyra et al. (2012)	282	92,908	89,259 to 95,614
Penesis et al. (2008)	63	68,254	55,311 to 79,415
Chisnoiu et al. (2016)	22	77,273	54,630 to 92,179
Trope et al. (1999)	102	73,529	63,871 to 81,776
Total (random effects)	7822	78,566	70,868 to 85,366
I^2 (inconsistency)			98,24%
95% CI for I^2			97,84 to 98,57

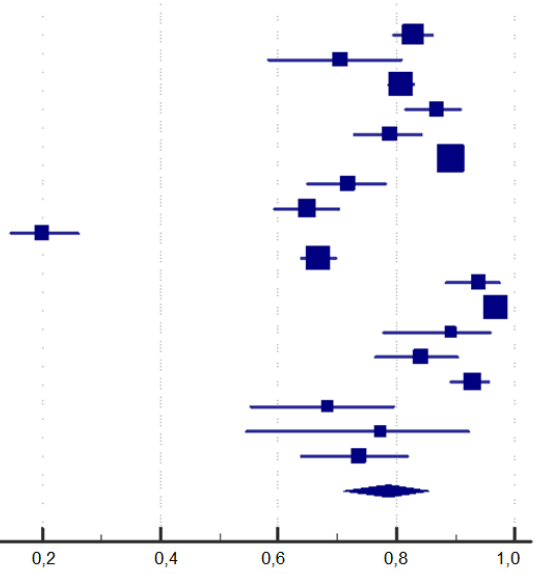


Figura 5. Meta-Analysis (Descriptive Observational; n=13).

Study	Sample size	Proportion (%)	95% CI
Monea et al. (2015)	71	70,423	58,407 to 80,670
Bernstein et al. (2012)	1311	80,854	78,618 to 82,951
Peters et al. (2004)	233	86,695	81,649 to 90,778
Pirani et al. (2014)	209	78,947	72,787 to 84,267
Ramey et al. (2017)	1960	89,082	87,617 to 90,429
Scott (2013)	188	71,809	64,800 to 78,115
Sidaravicius et al. (1999)	320	65,000	59,498 to 70,222
Tsesis et al. (2013)	200	20,000	14,689 to 26,223
Tavares et al. (2009)	1035	66,763	63,801 to 69,630
Fernández et al. (2013)	132	93,939	88,407 to 97,347
Fleming et al. (2010)	984	96,951	95,676 to 97,934
Moazami et al. (2011)	55	89,091	77,753 to 95,890
Eriksen et al. (1995)	121	84,298	76,570 to 90,273
Total (random effects)	6819	78,107	68,317 to 86,519
I^2 (inconsistency)			98,70 %
95% CI for I^2			98,38 to 98,96

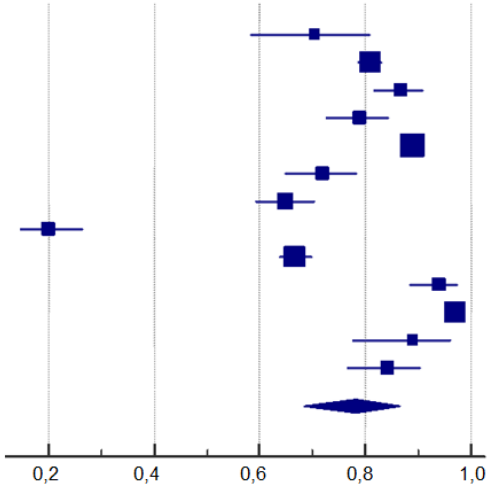


Figura 6. Meta-Analysis (Quasi-Experimental; n=3).

Study	Sample size	Proportion (%)	95% CI
Paredes-Vieyra et al. (2012)	282	92,908	89,259 to 95,614
Penesis et al. (2008)	63	68,254	55,311 to 79,415
Chisnoiu et al. (2016)	22	77,273	54,630 to 92,179
Total (fixed effects)	367	88,613	84,927 to 91,664
Total (random effects)	367	80,710	58,701 to 95,594
I^2 (inconsistency)			92,10 %
95% CI for I^2			80,10 to 96,87

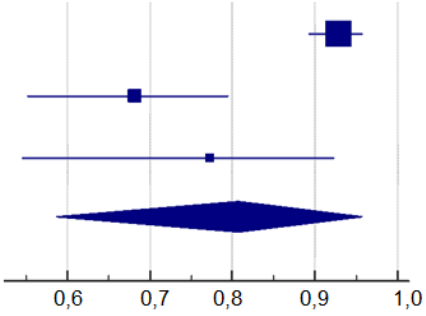


Figura 7. Meta-Analysis (Rx Periapical Convencional; n=12).

Study	Sample size	Proportion (%)	95% CI
Monea et al. (2015)	71	70,423	58,407 to 80,670
Bernstein et al. (2012)	1311	80,854	78,618 to 82,951
Pirani et al. (2014)	209	78,947	72,787 to 84,267
Ramey et al. (2017)	1960	89,082	87,617 to 90,429
Scott (2013)	188	71,809	64,800 to 78,115
Sidaravicius et al. (1999)	320	65,000	59,498 to 70,222
Tsesis et al. (2013)	200	20,000	14,689 to 26,223
Fernández et al. (2013)	132	93,939	88,407 to 97,347
Eriksen et al. (1995)	121	84,298	76,570 to 90,273
Paredes-Vieyra et al. (2012)	282	92,908	89,259 to 95,614
Chisnoiu et al. (2016)	22	77,273	54,630 to 92,179
Trope et al. (1999)	102	73,529	63,871 to 81,776
Total (random effects)	4918	76,074	65,986 to 84,870
I^2 (inconsistency)			98,04 %
95% CI for I^2			97,44 to 98,50

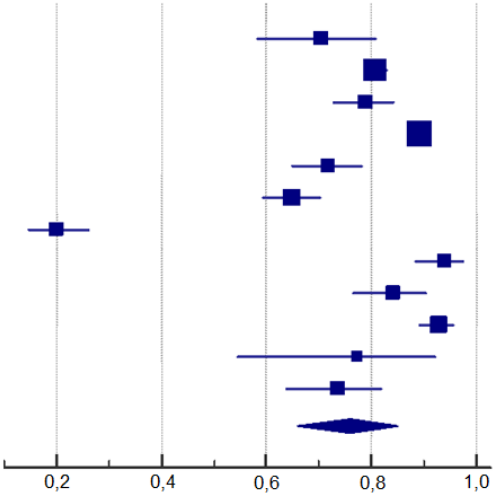


Figura 8. Meta-Analysis (Rx Periapical Digital; n=7).

Study	Sample size	Proportion (%)	95% CI
Dolci et al. (2016)	534	82,959	79,496 to 86,052
Peters et al. (2004)	233	86,695	81,649 to 90,778
Tavares et al. (2009)	1035	66,763	63,801 to 69,630
Fernández et al. (2013)	132	92,424	86,509 to 96,307
Fleming et al. (2010)	984	96,951	95,676 to 97,934
Moazami et al. (2011)	55	89,091	77,753 to 95,890
Penesis et al. (2008)	63	68,254	55,311 to 79,415
Total (random effects)	3036	84,613	71,568 to 94,174
I^2 (inconsistency)			98,53 %
95% CI for I^2			97,95 to 98,94

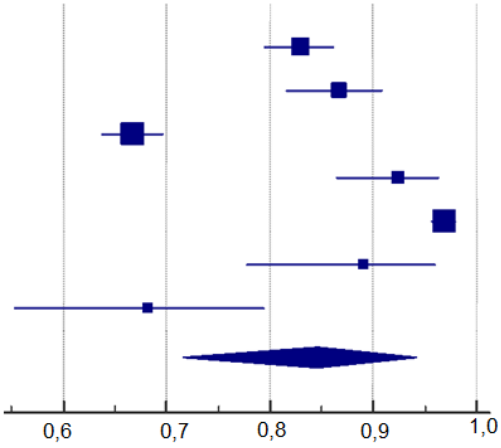


Figura 9. Meta-Analysis (Follow-Up until 13 months; n=7).

Study	Sample size	Proportion (%)	95% CI
Monea et al. (2015)	71	70,423	58,407 to 80,670
Scott (2013)	188	71,809	64,800 to 78,115
Fleming et al. (2010)	984	96,951	95,676 to 97,934
Moazami et al. (2011)	55	89,091	77,753 to 95,890
Penesis et al. (2008)	63	68,254	55,311 to 79,415
Chisnoiu et al. (2016)	22	77,273	54,630 to 92,179
Trope et al. (1999)	102	73,529	63,871 to 81,776
Total (random effects)	1485	79,338	63,102 to 91,773
I^2 (inconsistency)			96,77 %
95% CI for I^2			95,07 to 97,88

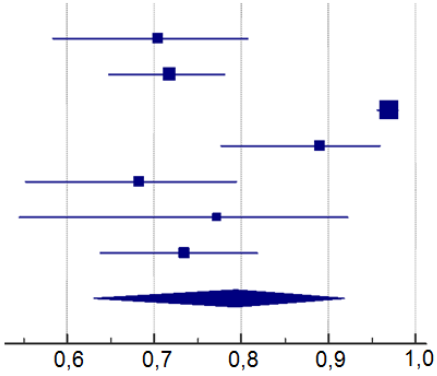


Figura 10. Meta-Analysis (Follow-Up more than 2 years; n=7).

Study	Sample size	Proportion (%)	95% CI
Bernstein et al. (2012)	1311	80,854	78,618 to 82,951
Peters et al. (2004)	233	86,695	81,649 to 90,778
Pirani et al. (2014)	209	78,947	72,787 to 84,267
Paredes-Vieyra et al. (2012)	282	92,908	89,259 to 95,614
Tsesis et al. (2013)	200	20,000	14,689 to 26,223
Fernández et al. (2013)	132	93,939	88,407 to 97,347
Eriksen et al. (1995)	121	84,298	76,570 to 90,273
Total (random effects)	2488	78,758	62,410 to 91,379
I^2 (inconsistency)			98,52 %
95% CI for I^2			97,94 to 98,93

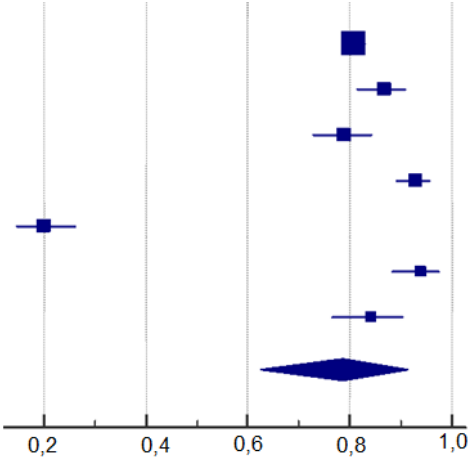


Figura 11. Meta-Analysis (Mechanical Instrumentation; n=7).

Study	Sample size	Proportion (%)	95% CI
Peters et al. (2004)	233	86,695	81,649 to 90,778
Fernández et al. (2013)	55	98,182	90,281 to 99,954
Fleming et al. (2010)	525	96,000	93,950 to 97,507
Moazami et al. (2011)	55	89,091	77,753 to 95,890
Paredes-Vieyra et al. (2012)	282	92,908	89,259 to 95,614
Penesis et al. (2008)	63	68,254	55,311 to 79,415
Chisnoiu et al. (2016)	22	77,273	54,630 to 92,179
Total (random effects)	1235	88,781	81,965 to 94,141
I^2 (inconsistency)			89,36 %
95% CI for I^2			80,59 to 94,17

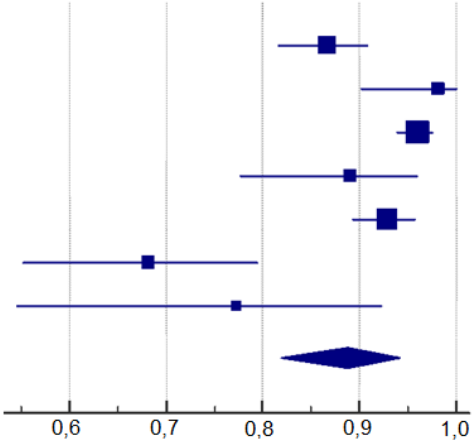


Figura 12. Meta-Analysis (Hand Instrumentation; n=4).

Study	Sample size	Proportion (%)	95% CI
Pirani et al. (2014)	209	78,947	72,787 to 84,267
Fernández et al. (2013)	77	90,909	82,162 to 96,266
Fleming et al. (2010)	459	98,039	96,311 to 99,100
Trope et al. (1999)	102	73,529	63,871 to 81,776
Total (random effects)	847	87,008	70,196 to 97,462
I^2 (inconsistency)			96,86 %
95% CI for I^2			94,36 to 98,25

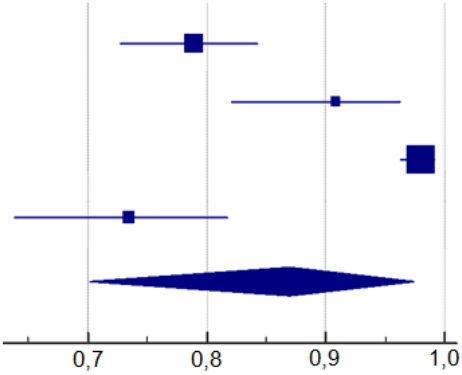


Figura 13. Meta-Analysis (Single-visit; n=6).

Study	Sample size	Proportion (%)	95% CI
Bernstein et al. (2012)	662	82,024	78,883 to 84,877
Fleming et al. (2010)	355	96,620	94,170 to 98,241
Moazami et al. (2011)	55	89,091	77,753 to 95,890
Paredes-Vieyra et al. (2012)	146	96,575	92,189 to 98,879
Penesis et al. (2008)	33	66,667	48,173 to 82,039
Trope et al. (1999)	45	80,000	65,404 to 90,424
Total (random effects)	1296	87,152	77,249 to 94,534
I^2 (inconsistency)			94,09 %
95% CI for I^2			89,72 to 96,61

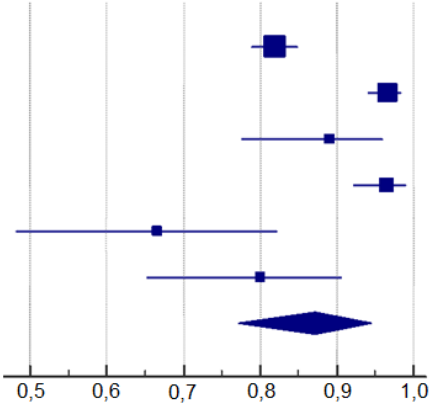


Figura 14. Meta-Analysis (Two-visits; n=7).

Study	Sample size	Proportion (%)	95% CI
Bernstein et al. (2012)	500	79,000	75,163 to 82,490
Sidaravicius et al. (1999)	320	65,000	59,498 to 70,222
Fleming et al. (2010)	534	98,127	96,583 to 99,098
Paredes-Vieyra et al. (2012)	136	88,971	82,462 to 93,694
Penesis et al. (2008)	30	70,000	50,604 to 85,265
Chisnoiu et al. (2016)	22	77,273	54,630 to 92,179
Trope et al. (1999)	31	80,645	62,527 to 92,548
Total (random effects)	1573	81,334	66,531 to 92,543
I^2 (inconsistency)			97,42 %
95% CI for I^2			96,18 to 98,26

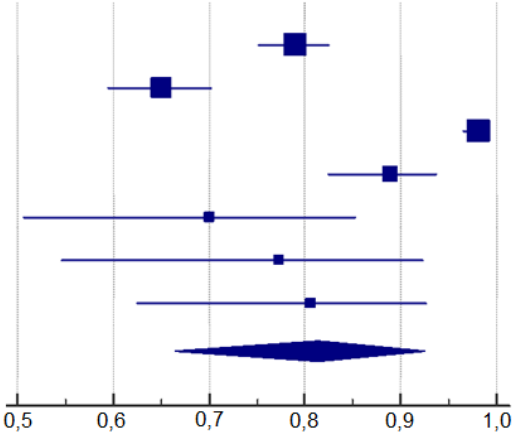


Tabela 1. Summary of cross-sectional characteristics of included articles (n=20).

Author, Year, Country	Type of study	Sample	Instrumentation technique	Professional training	Type of Rx	Follow-	Outcome
Ahmed et al. (2013) Pakistan	Randomized Controlled Trial	235 patients	Mechanical	Not specified	Periapical radiography	6 months	198 patients successfully
Bernstein et al. (2012) EUA	Descriptive Observational	1311 teeth	Not specified	General and endodontist	Periapical radiography	3-5 years	1060 teeth successfully

Chisnoiu et al. (2016) Romania	Quasi-experimental	22 teeth	Mechanical	Not specified	Periapical radiography	12 months	17 teeth successfully
Dolci et al. (2016) Italy	Analytical Cross-sectional	534 teeth	Not specified	Not specified	Digital radiography	Records from September 2007 to March 2008	443 teeth successfully
Eriksen et al. (1995) Norway	Descriptive Observational	121 teeth	Not specified	General dentist	Periapical radiography	20 years	102 teeth successfully

Fernández et al. (2013) Colombia	Descriptive Observational	132 teeth	Manual and mechanical	Dentists during endodontic postgraduate program	Periapical radiography, digital radiography and cone – beam computed tomography	5 years	124 teeth successfully
Fleming et al. (2010) EUA	Descriptive Observational	984 teeth	Manual and mechanical	Endodontists	Digital radiography	12 months	954 teeth successfully
Moazami et al. (2011) Iran	Descriptive Observational	55 teeth	Mechanical	Endodontists	Digital radiography	4 months	49 teeth successfully

Monea et al. (2015) Romania	Descriptive Observational	71 teeth	Not specified	Postgraduate students	Periapical radiography	12 months	50 teeth successfully
Paredes-Vieyra et al. (2012) Mexico	Quasi-experimental	282 teeth	Mechanical	Not specified	Periapical radiography	2 years	262 teeth successfully
Penesis et al. (2008) EUA	Quasi-experimental	63 teeth	Mechanical	Endodontic residents	Digital radiography	12 months	43 teeth successfully
Peters et al. (2004) EUA	Descriptive Observational	233 teeth	Mechanical	Not specified	Digital radiography	3 years	202 teeth successfully

Pirani et al. (2014) Italy	Descriptive Observational	209 teeth	Manual	Endodontists	Periapical radiography	10 years	165 teeth successfully
Ramey et al. (2017) EUA	Descriptive Observational	1960 teeth	Not specified	General and endodontists	Periapical radiography	Records from July 1 to October 15 (2011)	1746 teeth successfully
Saini et al. (2012) India	Quasi-experimental	129 patients	Manual	Not specified	Periapical radiography	12 months	97 patients successfully
Rodney V. Scott (2013) EUA	Descriptive Observational	188 teeth	Not specified	Endodontists and Endodontic residents	Periapical radiography	12 months	135 teeth successfully

Sidaraviciu s et al. (1999) Lithuania	Descriptive Observationa l	320 teeth	Not specified	Not specified	Periapical radiography	Not specified	208 teeth successfull y
Tavares et al. (2009) France	Descriptive Observationa l	1035 teeth	Not specified	Not specified	Digital radiography	Not specified	691 teeth successfull y
Trope et al. (1999) EUA	Randomized Controlled Trial	102 teeth	Manual	Not specified	Periapical radiography	13 months	75 teeth successfull y
Tsesis et al. (2013) Israel	Descriptive Observationa l	200 teeth	Not specified	Not specified	Periapical radiography	4 years	40 teeth successfull y

Tabela 2. GRADE's Summary of findings.

What is the success rate of primary root canal treatment in permanent teeth performed by dentists?

Settings: To summarize the available evidence, based in our described eligibility criteria, eighteen studies were selected and analyzed.

Outcomes	№ of participants (studies) Follow-up	Certainty of the evidence (GRADE)	Frequency of percutaneous injuries on dentists	
			Proportion %	95% CI
Success Rate	7822 teeth (18 studies)	⊕◯◯◯ VERY LOW[a,b]	78.56	70.86 to 85.36

Legend: CI, confidence interval; GRADE, grading of recommendations assessment, development and evaluation; MA, meta-analysis; PI, percutaneous injuries; RoB, risk of bias.

4 CONCLUSÃO

Dentro das limitações dos estudos incluídos e das baixas evidências encontradas, pode-se concluir que as taxas de sucesso do tratamento endodôntico inicial em dentes permanentes de humanos, realizado por cirurgiões dentistas, foi alta (78,56%). Nossos resultados identificaram que 'tempo de acompanhamento', tipo de instrumentação' e 'número de visitas (única ou duas visitas)' não teve influência no resultado final. Por esta razão, o profissional deve ser capaz de avaliar o método mais apropiado, de acordo com sua habilidade, experiência e o diagnóstico do paciente, para fornecer o melhor tratamento e alcançar estas taxas de resultados.

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APÊNDICE 1

Supplemntary Online Data

Supplemental Appendix 1: Database search strategy.

Database	Search
LILACS 04/07/17	(tw:("root canal therapy" OR "root canal therapies" OR "root canal treatment" OR "root canal treatments" OR "endodontic treatment" OR "endodontic therapy" OR "endodontic treatments" OR "endodontic therapies" OR "root canal obturation" OR "root canal obturations" OR "Endodontic Obturation" OR "Endodontic Obturations" OR "root canal filling" OR "root canal fillings" OR "root filling" OR "root fillings" OR "periapical healing" OR "periapical health" OR "tooth survival" OR "nonsurgical root canal treatment" OR "terapia de canal radicular" OR "terapias de canal radicular" OR "tratamento de canal radicular" OR "tratamentos de canal radicular" OR "tratamento endodôntico" OR "terapia endodôntica" OR "tratamentos endodônticos" OR "terapias endodônticas" OR "obturação de canal radicular" OR "obturações de canal radicular" OR "obturação endodôntica" OR "obturações endodônticas" OR "preenchimento do canal radicular" OR "preenchimentos do canal radicular" OR "preenchimento do canal" OR "preenchimentos do canal" OR "cura periapical" OR "saúde periapical" OR "dente sobrevivente" OR "tratamento de canal radicular não-cirúrgico" OR "terapia de conducto radicular" OR "terapias de canal radicular" OR "tratamiento de canal radicular" OR "tratamientos de canal radicular" OR "tratamiento endodóntico" OR "terapia endodóntica" OR "tratamientos endodónticos"

	OR "terapias endodónticas" OR "obturación de canal radicular" OR "obturaciones de canal radicular" OR "obturación endodóntica" OR "obturaciones endodónticas" OR "llenado del canal radicular" OR "llenados del canal radicular" OR "llenado del canal" OR "llenados del canal" OR "curación periapical" OR "salud periapical" OR "diente sobreviviente" OR "tratamiento de canal radicular no quirúrgico")) AND (tw:("tomography" OR "tomographies" OR "cone beam" OR "cone beams" OR "periapical radiography" OR "periapical radiograph" OR "periapical radiographies" OR "periapical radiographs" OR "radiography" OR "radiographies" OR "X-Ray" OR "X-Rays" OR "radiologic exam" OR "radiologic exams" OR "radiographic" OR "tomografia" OR "tomografias" OR "radiografia periapical" OR "periapical radiografia" OR "radiografias periapicais" OR "periapical radiografias" OR "radiografia" OR "radiografias" OR "raio-x" OR "raios-x" OR "exame radiológico" OR "exames radiológicos" OR "radiografías periapicales" OR "periapicales radiografías" OR "rayo X" OR "rayos-x" OR "examen radiológico" OR "exámenes radiológicos")) AND (tw:("success" OR "successful" OR "Clinical Effectiveness" OR "Clinical Efficacy" OR "Treatment Effectiveness" OR "Treatment Efficacy" OR "treatment outcome" OR "sucesso" OR "bem sucedido" OR "efetividade clinica" OR "eficácia clinica" OR "efetividade do tratamento" OR "eficácia do tratamento" OR "resultado do tratamento" OR "éxito" OR "exitoso" OR "efectividad clínica" OR "eficacia clinica" OR "efectividad del tratamiento" OR "eficacia del tratamiento" OR "resultado del tratamiento")) AND (instance:"regional") AND (db:("LILACS") AND type:("article"))

PubMed 04/07/17	(("root canal therapy"[MeSH Terms] OR "root canal therapy"[All Fields] OR "root canal therapies"[All Fields] OR "root canal treatment"[All Fields] OR "root canal treatments"[All Fields] OR "endodontic treatment"[All Fields] OR "endodontic therapy"[All Fields] OR "endodontic treatments"[All Fields] OR "endodontic therapies"[All Fields] OR "root canal obturation"[MeSH Terms] OR "root canal obturation"[All Fields] OR "root canal obturations"[All Fields] OR "Endodontic Obturation"[All Fields] OR "Endodontic Obturations"[All Fields] OR "root canal filling"[All Fields] OR "root canal fillings"[All Fields] OR "root filling"[All Fields] OR "root fillings"[All Fields] OR "periapical healing"[All Fields] OR "periapical health"[All Fields] OR "tooth survival"[All Fields] OR "nonsurgical root canal treatment"[All Fields]) AND ("tomography"[MeSH Terms] OR "tomography"[All Fields] OR "tomographies"[All Fields] OR "cone beam"[All Fields] OR "cone beams"[All Fields] OR "periapical radiography"[All Fields] OR "periapical radiograph"[All Fields] OR "periapical radiographies"[All Fields] OR "periapical radiographs"[All Fields] OR "Radiography, Dental, Digital"[MeSH Terms] OR "Radiography, Dental"[MeSH Terms] OR "radiography"[All Fields] OR "radiography"[MeSH Terms] OR "radiographies"[All Fields] OR "X-Ray"[All Fields] OR "X-Rays"[All Fields] OR "radiologic exam"[All Fields] OR "radiologic exams"[All Fields] OR "radiographic"[All Fields])) AND ("success"[All Fields] OR "successful"[All Fields] OR "Clinical Effectiveness"[All Fields] OR "Clinical Efficacy"[All Fields] OR

	"Treatment Effectiveness"[All Fields] OR "Treatment Efficacy"[All Fields] OR "treatment outcome"[All Fields])
Scopus 04/07/17	(TITLE-ABS-KEY ("root canal therapy" OR "root canal therapies" OR "root canal treatment" OR "root canal treatments" OR "endodontic treatment" OR "endodontic therapy" OR "endodontic treatments" OR "endodontic therapies" OR "root canal obturation" OR "root canal obturations" OR "Endodontic Obturation" OR "Endodontic Obturations" OR "root canal filling" OR "root canal fillings" OR "root filling" OR "root fillings" OR "periapical healing" OR "periapical health" OR "tooth survival" OR "nonsurgical root canal treatment")) AND (TITLE-ABS-KEY ("tomography" OR "tomographies" OR "cone beam" OR "cone beams" OR "periapical radiography" OR "periapical radiograph" OR "periapical radiographies" OR "periapical radiographs" OR "radiography" OR "radiographies" OR "X-Ray" OR "X-Rays" OR "radiologic exam" OR "radiologic exams" OR "radiographic")) AND (TITLE-ABS-KEY ("success" OR "successful" OR "Clinical Effectiveness" OR "Clinical Efficacy" OR "Treatment Effectiveness" OR "Treatment Efficacy" OR "treatment outcome")) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "ip"))
Web of Science 04/07/17	("root canal therapy" OR "root canal therapies" OR "root canal treatment" OR "root canal treatments" OR "endodontic treatment" OR "endodontic therapy" OR "endodontic treatments" OR "endodontic therapies" OR "root canal obturation" OR "root canal obturations" OR "Endodontic Obturation" OR "Endodontic Obturations" OR "root canal filling" OR "root

	canal fillings" OR "root filling" OR "root fillings" OR "periapical healing" OR "periapical health" OR "tooth survival" OR "nonsurgical root canal treatment") AND ("tomography" OR "tomographies" OR "cone beam" OR "cone beams" OR "periapical radiography" OR "periapical radiograph" OR "periapical radiographies" OR "periapical radiographs" OR "radiography" OR "radiographies" OR "X-Ray" OR "X-Rays" OR "radiologic exam" OR "radiologic exams" OR "radiographic") AND ("success" OR "successful" OR "Clinical Effectiveness" OR "Clinical Efficacy" OR "Treatment Effectiveness" OR "Treatment Efficacy" OR "treatment outcome")
Google Scholar 06/08/17	("root canal treatment" OR "endodontic treatment" OR "root canal obturation") AND ("tomography" OR "cone beam" OR "periapical radiography" OR "periapical radiograph" OR "periapical radiographies") AND ("success" OR "treatment outcome")
OpenGrey 04/07/17	("root canal therapy" OR "root canal therapies" OR "root canal treatment" OR "root canal treatments" OR "endodontic treatment" OR "endodontic therapy" OR "endodontic treatments" OR "endodontic therapies" OR "root canal obturation" OR "root canal obturations" OR "Endodontic Obturation" OR "Endodontic Obturations" OR "root canal filling" OR "root canal fillings" OR "root filling" OR "root fillings" OR "periapical healing" OR "periapical health" OR "tooth survival" OR "nonsurgical root canal treatment") AND ("tomography" OR "tomographies" OR "cone beam" OR "cone beams" OR "periapical radiography" OR "periapical radiograph" OR "periapical radiographies" OR "periapical radiographs" OR "radiography" OR "radiographies" OR "X-Ray" OR "X-Rays" OR "radiologic exam" OR

	"radiologic exams" OR "radiographic") AND ("success" OR "successful" OR "Clinical Effectiveness" OR "Clinical Efficacy" OR "Treatment Effectiveness" OR "Treatment Efficacy" OR "treatment outcome")
ProQuest 04/07/17	ALL("root canal therapy" OR "root canal therapies" OR "root canal treatment" OR "root canal treatments" OR "endodontic treatment" OR "endodontic therapy" OR "endodontic treatments" OR "endodontic therapies" OR "root canal obturation" OR "root canal obturations" OR "Endodontic Obturation" OR "Endodontic Obturations" OR "root canal filling" OR "root canal fillings" OR "root filling" OR "root fillings" OR "periapical healing" OR "periapical health" OR "tooth survival" OR "nonsurgical root canal treatment") AND ALL("tomography" OR "tomographies" OR "cone beam" OR "cone beams" OR "periapical radiography" OR "periapical radiograph" OR "periapical radiographies" OR "periapical radiographs" OR "radiography" OR "radiographies" OR "X-Ray" OR "X-Rays" OR "radiologic exam" OR "radiologic exams" OR "radiographic") AND ALL("success" OR "successful" OR "Clinical Effectiveness" OR "Clinical Efficacy" OR "Treatment Effectiveness" OR "Treatment Efficacy" OR "treatment outcome")

APÊNDICE 2

Supplementary Online Data

Supplemental Appendix 2: Excluded articles with reasons of exclusion (n=75).

Author, Year	Reason for exclusion
Akbar et al. 2013	1
Angerame et al. 2013	7
Angerame et al. 2016	1
Angerame et al. 2017	1
Aqrabawi et al. 2006	7
Barbakow et al. 1981	1
Bierenkrant et al. 2008	7
Boltacz-Rzepkowska et al. 2003	1
Castelot-Enkel et al. 2013	2
Chugal et al. 2003	1
De Chevigny et al. 2008	2
Diogo et al. 2014	7
Eriksen et al. 1988	4
Ertas et al. 2013	1
Espíndola et al. 2002	2
Ferreira et al. 2007	6
Field et al. 2004	7
Fonzar et al. 2009	3
Friedman et al. 1995	1
Gesi et al. 2006	1
Gilbert et al. 2010	7
Grossman et al. 1964	2
Guerra Pando et al. 1992	1
Gulsum et al. 2014	1
Gunduz et al. 2011	5
Heling et al. 2001	7
Helminen et al. 2000	7
Hoskinson et al. 2002	1

Huumonen et al. 2013	2
Ilic et al. 2014	5
Jokinen et al. 1978	2
Jordan et al. 2014	7
K Balto et al. 2013	9
Koral et al. 2011	1
Lee et al. 2012	1
Liang et al. 2011	4
Liang et al. 2012	1
Liang et al. 2013	1
Martins et al. 2012	2
Molander et al. 2007	1
Morse et al. 1983	7
Murakami et al. 2002	7
Ng et al. 2011	1
Orstavik et al. 2004	2
Ozer et al. 2006	1
Ozer et al. 2009	1
Patel et al. 2012	7
Patil et al. 2016	7
Peak et al. 1994	1
Peak et al. 2001	1
Pedro et al. 2016	5
Peters et al. 2002	1
Petersson et al. 2015	1
Polycarpou et al. 2005	6
Pontes et al. 2013	6
Prashanth et al. 2011	7
Ramar et al. 2010	3
Ricucci et al. 2011	1
Saidi et al. 2015	1
Sarin et al. 2016	1
Shah et al. 1988	1
Siqueira et al. 2005	2
Sjogren et al. 1990	2
Skudutyte-Rysstad et al. 2006	2
Smith et al. 1993	1
Soares et al. 2001	1

Song et al. 2014	1
Van der Borden et al. 2013	6
Wong et al. 2015	1
Yousuf et al. 2015	1
Zhang et al. 2015	1
Zhu et al. 2007	8
Zhuang et al. 2007	8
Zmener et al. 1999	1
Zmener et al. 2012	1

1) Literature reviews, case reports, letters, personal opinions, conference abstracts; 2) Studies including deciduous teeth or permanent teeth without complete root formation; 3) Studies performing endodontic retreatment or surgery; 4) Studies which root treatment was performed by dental students or undergraduate students; 5) Studies based on panoramic radiography; 6) Studies that did not use PAI as method of evaluation radiographic images; 7) In vitro and ex vivo studies; 8) Studies with duplicated data from previously included studies; 9) Studies that did not have all information necessary (and we couldn't get in touch with the author).

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APÊNDICE 3

Risk of Bias: Randomized Controlled Trial and Quasi-Experimental (n=6).

Question	Ahmed *et al.* (2013)	Chisnoiu *et al.* (2016)	Paredes-Vieyra *et al.* (2012)	Penesis *et al.* (2008)	Saini *et al.* (2012)	Trope *et al.* (1999)
1. Is the assignment to treatment groups truly random?	Y	N	N	N	N	Y
2. Are participants blinded to treatment allocation?	U	U	N	N	Y	N
3. Is allocation to treatment groups concealed from the allocator?	U	U	N	N	N	Y
4. Are the outcomes of people who withdrew described and included in the analysis?	Y	Y	N	Y	Y	N
5. Are those assessing the outcomes blind to the treatment allocation?	U	U	Y	Y	Y	Y
6. Are the control	NA	NA	NA	NA	NA	NA

and treatment groups comparable at entry?						
7. Are groups treated identically other than for the named intervention?	Y	N	Y	Y	Y	Y
8. Are outcomes measured in the same way for all groups?	Y	Y	Y	Y	Y	Y
9. Are outcomes measured in a reliable way?	Y	Y	Y	Y	Y	Y
10. Is appropriate statistical analysis used?	Y	Y	Y	Y	Y	Y
%yes/risk	66%	44%	55%	66%	77%	77%

Legend - Y=Yes, N=No, U=Unclear, NA=Not applicable.

Risk of Bias: Descriptive Observational (n=13).

Question	Bernstein *et al.* (2012)	Eriksen *et al.* (1995)	Fernández *et al.* (2013)	Fleming *et al.* (2010)	Moazami *et al.* (2011)	Monea *et al.* (2015)	Peters *et al.* (2004)	Pirani *et al.* (2014)	Ramey *et al.* (2017)	Scott (2013)	Sidaravicius *et al.* (1999)	Tavares *et al.* (2009)	Tsesis *et al.* (2013)
1. Was study based on a random or pseudo-random sample?	Y	Y	Y	Y	N	Y	N	N	Y	N	Y	N	N
2. Were the criteria for inclusion in the sample clearly defined?	Y	N	N	Y	N	Y	Y	Y	NA	Y	N	N	Y
3. Were the confounding factors	N	Y	NA	Y	N	Y	NA	Y	Y	Y	N	Y	Y

identified and strategies to deal with them stated?													
4. Were outcomes assessed using objective criteria?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
5. If comparisons are being made, were there sufficient descriptions of the groups?	NA	NA	Y	Y	N	NA	Y	NA	Y	NA	Y	NA	NA
6. Was the follow up carried out a sufficien	Y	Y	Y	Y	Y	N	Y	Y	U	Y	U	U	Y

t time period?													
7. Were the outcomes of people who withdrew described and included in the analysis?	N	Y	U	U	N	NA	Y	Y	Y	NA	Y	NA	NA
8. Were outcomes measured in a reliable way?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
9. Was appropriate statistical analysis used?	Y	U	Y	Y	Y	Y	Y	Y	Y	Y	U	Y	Y
% yes/risk	75	75	75	88	6	85	87	87	87	85	55	57	85

Legend - Y=Yes, N=No, U=Unclear, NA=Not applicable.

Risk of Bias: Analytical cross-sectional (n=1).

Question	Dolci *et al.* (2016)
1. Were the criteria for inclusion in the sample clearly defined?	U
2. Were the study subjects and the setting described in detail?	N
3. Was the exposure measured in a valid and reliable way?	Y
4. Were objective, standard criteria used for measurement of the condition?	Y
5. Were confounding factors identified?	Y
6. Were strategies to deal with confounding factors stated?	N
7. Were the outcomes measured in a valid and reliable way?	Y
8. Was appropriate statistical analysis used?	Y
%yes/risk	62,5%

Legend - Y=Yes, N=No, U=Unclear, NA=Not applicable.

UNIVERSIDADE FEDERAL DE SANTA CATARINA
CENTRO DE CIENCIAS DA SAÚDE
CURSO DE ODONTOLOGIA
DISCIPLINA DE TRABALHO DE CONCLUSÂO DE CURSO DE ODONTOLOGIA

ATA DE APRESENTAÇÃO DO TRABALHO DE CONCLUSÃO DE CURSO

Aos 22 dias do mês de maio de 2018, às 10:00 horas, em sessão pública no (a) sala 901 desta Universidade, na presença da Banca Examinadora presidida pelo Professor Dayane Machado Ribeiro e pelos examinadores:

1 - Kamile Leonardi Dutra,

2 - Beatriz Dulcimira Mendes de Souza,

o aluno Maria Eduarda Pereira de Carvalho apresentou o Trabalho de Conclusão de Curso de Graduação intitulado:

Taxas de Sucesso do Tratamento endodôntico: uma Revisão Sistemática e Meta-Análise.

como requisito curricular indispensável à aprovação na Disciplina de Defesa do TCC e a integralização do Curso de Graduação em Odontologia. A Banca Examinadora, após reunião em sessão reservada, deliberou e decidiu pela aprovação do referido Trabalho de Conclusão do Curso, divulgando o resultado formalmente ao aluno e aos demais presentes, e eu, na qualidade de presidente da Banca, lavrei a presente ata que será assinada por mim, pelos demais componentes da Banca Examinadora e pelo aluno orientando.

Presidente da Banca Examinadora

Examinador 1

Examinador 2

Maria Eduarda Pereira
Aluno