

Rotary versus Manual Instrumentation for Root Canal Preparation in Primary Teeth: A Systematic Review and Meta-Analysis of Clinical Trials

Abstract

Objectives: The aim of this systematic review was to assess the scientific evidence on the effect of rotary versus manual instrumentation for root canal preparation in primary teeth. **Materials and Methods:** Search terms were selected based on Medical Subject Headings (MeSH) and non-MeSH terms. Electronic database search of English published literature was performed in March 2020 within the following databases: Scopus, Cochrane, PubMed, and Embase. The risk of bias of selected studies was assessed by means of Cochrane collaboration tool. The heterogeneity level among the included studies was measured by I^2 index. For statistical analysis of instrumentation time, standard mean difference (SMD) of continuous data was analyzed with 95% confidence intervals (95% CIs) using the fixed-effects model. A random-effects model was used for analysis of odds ratio (OR) to assess the probability of optimal fill, underfill, and overfill obturations. Forest plots were applied to show the results and to estimate the effectiveness of rotary instrumentation. **Results:** Seven articles were selected for this review. The SMD in rotary techniques was 1.79 min less than manual techniques (95% CI: -2.56–-1.03 min) and had a significant $P = 0.001$. The OR of optimum quality was calculated to be 3.53 (95% CI: 1.79–6.97) in the rotary technique at $P = 0.254$. **Conclusions:** Within the limitations of this review, it can be asserted that rotary files decrease the instrumentation time and increase the rates of optimally filled canals in primary teeth. However, these files do not decrease the risk of underfilling and overfilling compared to manual files.

Keywords: Instrumentation, manual file, primary tooth, rotary file

Introduction

The early loss of primary molars is one of the most important concerns in pediatric dentistry. Therefore, increasing importance is given to the retention of primary teeth until the eruption of permanent ones.^[1,2] Pulpectomy is considered to be treatment of choice for primary teeth with pulp involvement. This procedure has been performed using various instrumentation techniques. Although hand instrumentation by means of stainless steel files is the conventional method for root canal preparation in primary teeth, nickel–titanium rotary systems have been introduced recently.^[3,4]

The superiority of rotary systems has been reported in several clinical studies on permanent teeth.^[3] Considering the use of rotary files in primary teeth, review articles have been published in recent years.^[5-7] Reduced chair time, funnel-shaped canal

preparation which in turn produces uniform fill of the obturation paste, quick removal of the tissue and debris as well as increased patient cooperation are among various reported advantages of using these systems for instrumentation in primary teeth. However, increased risk of perforation or file fracture, overfill of the obturation paste, high cost, and the need for training have been considered as disadvantages of the use of rotary files in primary teeth.^[1,6] In addition, it has been argued that there is a lack of clinical data to compare rotary technique with the standard manual technique for instrumentation of root canals in primary teeth.^[7]

To our knowledge, there is no systematic review of randomized clinical trials (RCTs) comparing the use of rotary systems with manual files in primary teeth. Hence, we aimed to systematically review the RCTs to evaluate the effect of manual versus rotary files on the obturation quality and required chair time of primary tooth pulpectomies.

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Materials and Methods

This systematic review was conducted according to the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement.^[8] The methodology of this systematic review was developed based on a published systematic review conducted by the authors.^[9]

Search strategy

After defining a well-focused PICO question and inclusion/exclusion criteria [Table 1] according to the article's subject, we began to search for relevant studies. The articles which were about pulpectomies of primary teeth (P, population) instrumented by application of rotary files (I, intervention), compared to manual files (C, comparison), and assessed instrumentation time, obturation time, and obturation quality as primary outcomes (O, outcome) were chosen.

The keywords were selected based on Medical Subject Headings (MeSH) and non-MeSH terms in simple or multiple conjunctions. The searched databases were Embase, Scopus, Cochrane, and PubMed, and no filters were applied except for language (only the studies in English language were analyzed). Moreover, a hand search was done to obtain the articles that were probably missed. The manual search was done by checking the references of previously published review articles. In addition, we conducted a page-by-page search of journals and conference proceedings and abstracts. If we found any relevant article, we checked its eligibility for inclusion in the study. The latest date for searching in this study was March 2020. The search strategy of each database is shown in Table 2.

Selection of studies

Two authors (DT and KA) independently searched the mentioned databases using the developed search strategy and then reviewed the abstracts of the articles and chose the studies that were in accordance with the described inclusion criteria. The full texts of selected abstracts were screened, and some studies were excluded in this stage. The correlation coefficients between the search results of two authors in the abstract and full-text levels were 0.92 and 1, respectively. If there was any disagreement between two authors, the third author (RF) assessed the disagreement and made the final decision.

Table 1: Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
English language clinical studies that investigated the effectiveness of using rotary files for the pulpectomy of the primary teeth compared to manual file	Case reports Editorial letters Pilot studies Historical reviews Studies in languages other than English Cohorts

Assessment of risk of bias

Each selected study was evaluated for inner methodological risk of bias according to the Cochrane collaboration tool which considers selection, performance, detection, attrition, reporting, and other sources of bias (including industry-related bias or professional interest) and uses three terms for reporting them: high risk of bias, unclear risk of bias, and low risk of bias. Then, each article included in this review was classified based on the risk of bias through this approach: trials with at least one item designated to be at high risk of bias were regarded as having an overall high risk of bias. Trials with unclear risk of bias for one or more key domains were considered to be at moderate risk of bias, and trials with low risk of bias in all domains were rated as having overall low risk of bias.

The following data were collected for each study: authors' name, publication year, samples' characteristics, intervention and control conditions, number of included samples in each group, evaluated outcome, and final conclusion.

After gathering information, the possibility of preparing a meta-analysis was judged, and three studies were confirmed for analysis based on obturation quality outcome and four studies were included in the meta-analysis with respect to instrumentation time by an independent statistician and epidemiologist. Due to lack of sufficient studies, obturation time as an outcome was not considered for the meta-analysis.

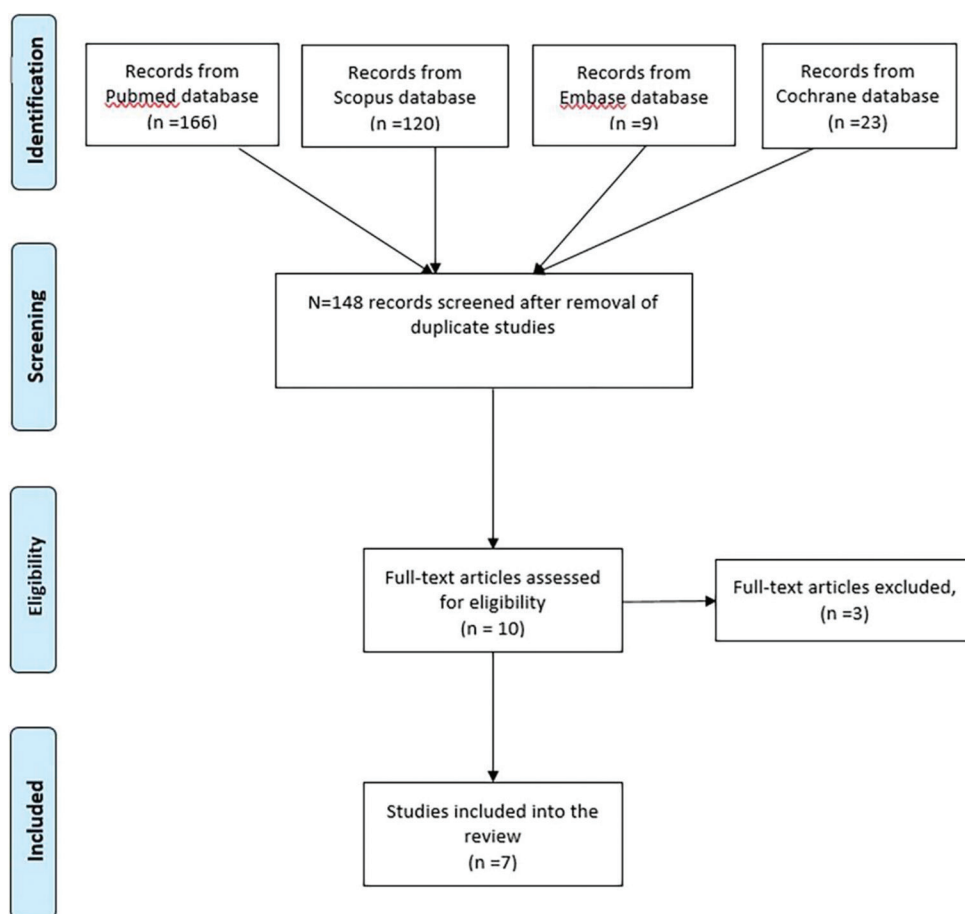
Meta-analysis was done to compare the effect of rotary instrumentation on obturation quality and instrumentation time of primary tooth pulpectomies by using CMA version 2 software (Biostat, Englewood, NJ, USA). For statistical analysis of instrumentation time, standard mean difference (SMD) of continuous data was analyzed with 95% confidence intervals (95% CIs) using the fixed-effects model, while for the obturation quality, odds ratio (OR) of optimal, underfill, and overfill teeth were assessed based on the random-effects model. Heterogeneity between the studies was investigated, and forest plots were applied to show the results of the meta-analysis.

Results

A flow diagram of the search strategy is presented in Figure 1. The search resulted in total of 318 articles (9 on Embase, 23 on Cochrane, 120 on Scopus, and 166 on MEDLINE [PubMed]). After excluding similar and none relevant studies, abstracts of 148 articles were assessed. Then, ten articles remained for full-text analysis. Among which, three^[10-12] were excluded as a reason described in Table 3. Finally, seven remained articles^[3,6,7,13-16] were selected for inclusion in the evidence table. The descriptive results and parameters recorded for each study are presented in Table 4.

Table 2: Search strategy applied for each database

Database	Search strategy
PubMed/Cochrane	(Primary teeth or deciduous teeth or primary molars) and (kedo.s rotary file or rotary file or race rotary file or protaper rotary file or smart rotary technique or k3 rotary file or rotary system or mtwo file or Ni_Ti protaper file or rotary instrumentation or Ni_Ti rotary file) and (manual instrumentation or conventional k file or Ni_Ti hand file or hand instrumentation or k_hand file or Ni_Ti k_flex file or manual hedstrom or H_file or stainless steel k_file or twisted file or hand file) and (root canal preparation or quality of obturation or instrumentation time or quality of preparation or cleaning or clinical time or obturation or faster shaping or cleaning or shaping)
Scopus/Embase	("primary teeth" or " deciduous teeth" or "primary molars") and ("kedo.s rotary file" or "rotary file" or "race rotary file" or "protaper rotary file" or "smart rotary technique" or "k3 rotary file" or "rotary system" or "mtwo file" or "rotary mtwo file" or "Ni_Ti protaper file" or "rotary instrumentation") and ("manual instrumentation" or "conventional k file" or "Ni_Ti hand file" or "hand instrumentation" or "k_hand file" or "Ni_Ti k_flex file" or "manual hedstrom" or "H_file" or "stainless steel k_file" or "twisted file" or "hand file") and ("root canal preparation" or "quality of obturation" or "instrumentation time" or "quality of preparation" or "cleaning efficacy" or "clinical time" or "faster shaping" or "cleaning " or "shaping")

**Figure 1: Study flow diagram on the identification of eligible studies**

The details of the assessment of risk of bias are shown in Figure 2. All of the included articles were at high risk of bias due to the lack of allocation concealment. The study by Vieyra and Enriquez was at high risk of bias as a result of high risk of reporting bias as well as lack of allocation concealment.

All the reviewed articles were RCTs describing a total of 341 primary teeth divided into intervention and control groups in which rotary instruments versus manual files

were used, respectively. Types of rotary applied systems varied among investigated studies. ProTaper rotary system,^[6,15] K3 rotary files,^[6,13] Mtwo rotary file,^[16] Kedo-S file,^[14] LightSpeed file,^[15] and FlexMaster system^[3,7] were different types of rotary systems used in the investigated studies. Manual instrumentation was applied for root canal preparation in control groups of all included studies.

Investigated studies set various outcomes as primary goals. All studies compared instrumentation time and obturation

quality between rotary and manual files except the study conducted by Vieyra and Enriquez^[15] that did not report the results of the obturation quality comparison between groups and was not included in this systematic review based on this outcome. In addition, obturation quality was another reported outcome in four articles.^[3,7,13,14]

Table 3: Excluded studies at full-text level with reason

Study	Reason for exclusion
N Mokhtari 2017	Unclear reporting
M Nair 2018	Different intervention condition
G Topcuoglu 2017	Different intervention condition

By considering the methodology and reporting of the included studies, three investigations^[13,14,16] were found to have sufficient homogeneity for meta-analysis based on obturation quality. While, for the instrumentation time, the number of similar studies was four.^[3,7,13,14] Due to the lack of sufficient studies with enough similarities, a meta-analysis could not be applied for the assessment of the obturation quality.

Results of selected studies were included in random model meta-analysis based on three types of obturation quality, and four studies were assessed by fixed model

Table 4: Evidence table

Author/year	Participants	Type of teeth	Intervention	Control	Evaluated outcome	Result
Lavanya Gonvindaraju (2017)	Children aged 4-8 years	45 primary molars	G1: 15 teeth/s2 ProTaper file G2: 15 teeth/K3 file	15 teeth/manual file	Quality of obturation and instrumentation time	Obturation quality: The hand file and rotary systems performed similarly ($P=0.791$) Instrumentation time: Rotary system < Hand file ($P<0.001$)
Lavanya Gonvindaraju and Ganesh Jeevanandan (2017)	Children aged 4-8 years	45 primary molars	G1: 15 teeth/S2 ProTaper file G2: 15/Mtwo file	15 teeth/manual file	Quality of obturation and instrumentation time	Obturation quality: The hand file and rotary systems performed similarly ($P>0.05$) Instrumentation time: Rotary system < hand file ($P=0.000$)
R. Morankar (2018)	Children aged 4-7 years	60 primary molars	60 roots/hyflex-CM Ni-Ti file	60 roots/manual file	Quality of obturation and instrumentation time and obturation time	Obturation quality: The hand file and rotary systems performed similarly ($P=0.40$) instrumentation time: Rotary system < hand file ($P<0.001$) Obturation time: No difference between groups ($P=0.07$)
G. Jeevanandan L. Gonvindaraju (2018)	Children aged 4-7 years	60 primary molars	30 teeth/Kedo-S files	30 teeth/manual file	Quality of obturation and instrumentation time	Obturation quality: Significant improvement in obturation quality with rotary file ($P<0.05$) Instrumentation time: Rotary system < hand file ($P<0.001$)
Tania Ochoa-romero (2011)	Children aged 5-9 years	40 primary molars	20 teeth/K3 file	20 teeth/manual file	Quality of obturation and instrumentation time and obturation time	Obturation quality: Significant improvement in obturation quality with rotary file ($P<0.05$) Instrumentation time: Rotary system < hand file ($P=0.002$) Obturation time: Rotary system < hand file ($P=0.009$)
Abbas Makarem (2013)	Children aged 3-6 years	46 primary molars	23 mesial roots and 23 distal roots/flex master file	23 mesial roots and 23 distal roots/manual file	Quality of obturation and instrumentation time and obturation time	Obturation quality: Significant improvement in obturation quality in mesial roots with rotary file but not in distal roots ($P<0.0015/P=0.986$) Instrumentation time: Rotary system < hand file ($P<0.001$) Obturation time: No difference between groups ($P=0.245$)
Vieyra JP and Enrique FJJ (2014)	Children aged 4-7 years	45 primary molars	G1: 15 teeth/light speed LSX file G2: 15 teeth/ProTaper file	G3:15 teeth/manual file	Instrumentation time	Instrumentation time: Rotary system < hand file ($P<0.005$)

	a.	b.	c.	d.	e.	f.	g.
Lavanya gonvindaraju 2017	+	-	?	+	+	+	+
Lavanya gonvindaraju 2017	+	-	?	+	+	+	+
R.morankar 2018	+	-	?	+	+	+	+
G.jeevanandan L.gonvindaraju 2018	+	-	?	+	+	+	+
Tania ochoa-romero 2011	+	-	?	?	+	+	+
Abbas makarem 2013	+	-	?	+	+	+	+
Vieyra JP & Enrique FJJ 2014	+	-	?	?	+	-	+

a. Random sequence generation (selection bias)

b. Allocation concealment (selection bias)

c. Blinding of participants and personnel (performance bias)

d. Blinding of outcome assessment (detection bias)

e. Incomplete outcome data (attrition bias)

f. Selective reporting (reporting bias)

g. Other bias

+ Low risk of bias
? Unclear risk of bias
- High risk of bias

Figure 2: Risk of bias assessment

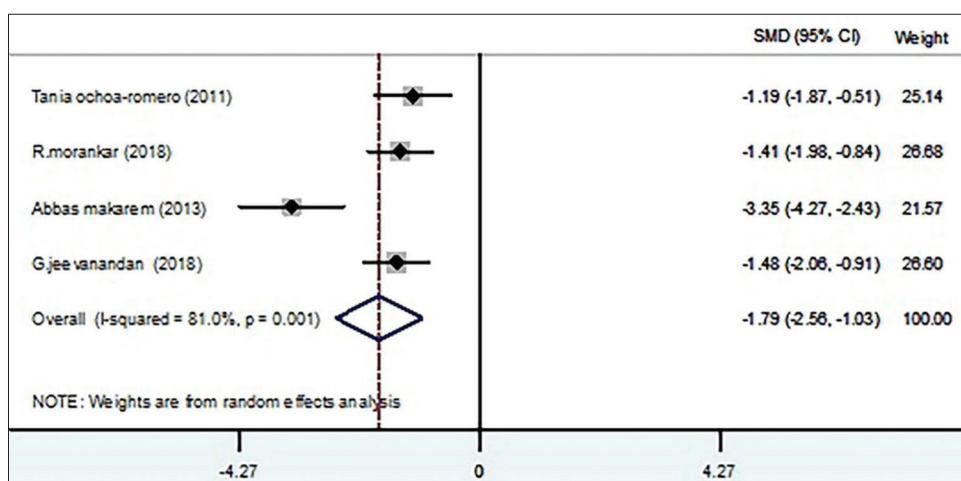


Figure 3: Forest plot based on instrumentation time

meta-analysis based on instrumentation time. I^2 index was applied for heterogeneity test, and the results are shown in Figures 3-6.

Although, it was found that rotary files significantly decrease the instrumentation time of pulpectomy of primary teeth compared to manual systems. The SMD in rotary techniques was 1.79 min less than manual techniques (95% CI: -2.56–-1.03 min) and had a significant $P = 0.001$. Mixed results were found for the obturation quality. The OR of optimum quality was calculated to be 3.53 (95% CI: 1.79–6.97) in the rotary technique at $P = 0.254$. However, for overfilled and underfilled quality, the ORs were 0.58 (95% CI: 0.27–1.26) and 0.45 (95% CI: 0.19–1.11), respectively. The accompanying forest plots and the weight of each study are shown in Figures 3-6.

Discussion

This systematic review was aimed to assess the scientific evidence on using rotary versus manual instrumentation for pulpectomy of primary teeth. The results of this review indicated that root canal instrumentation by rotary systems significantly decreases the instrumentation time in primary tooth pulpectomies. Furthermore, promising performance of these systems was revealed with respect to the quality of obturation.

Instrumentation time by rotary systems in comparison to manual files in primary and permanent teeth has been assessed by previous *in vitro* studies. Similar to the results of this systematic review of clinical trials, *in vitro* studies have revealed the reduction of instrumentation time by the rotary technique.^[17-21] In pediatric dentistry, the duration

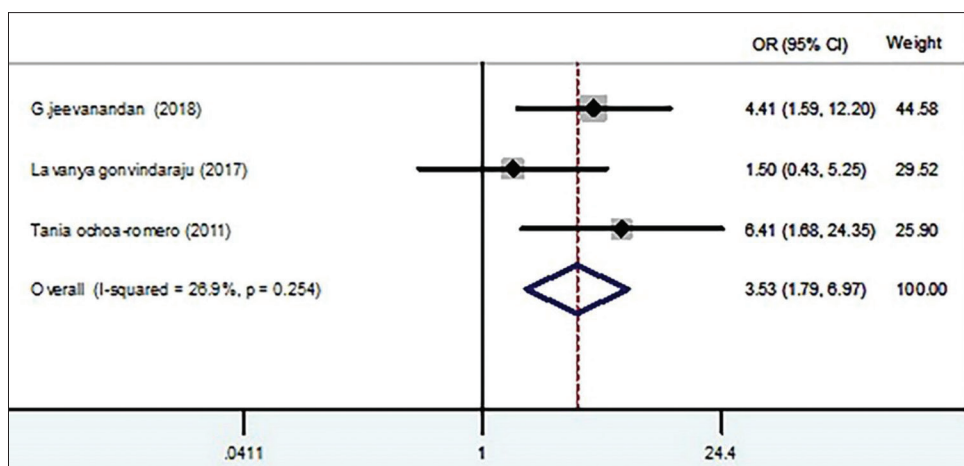


Figure 4: Forest plot based on optimally filled canals

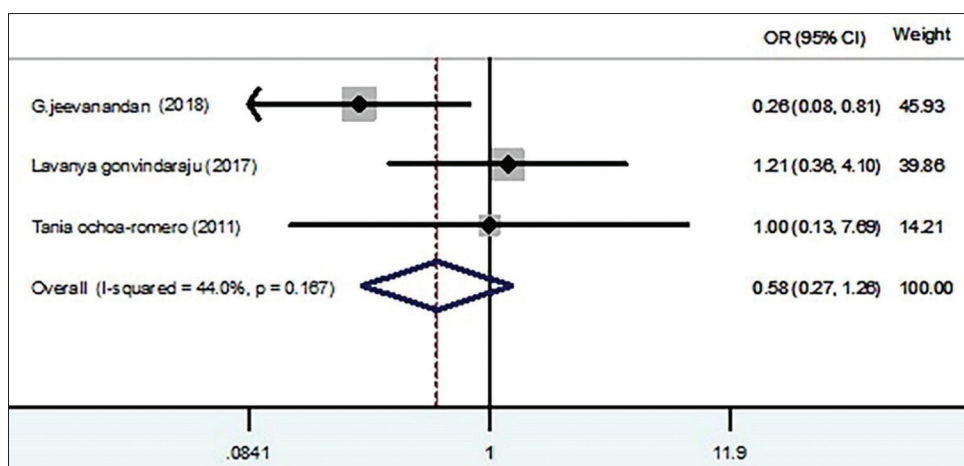


Figure 5: Forest plot based on overfilled canals

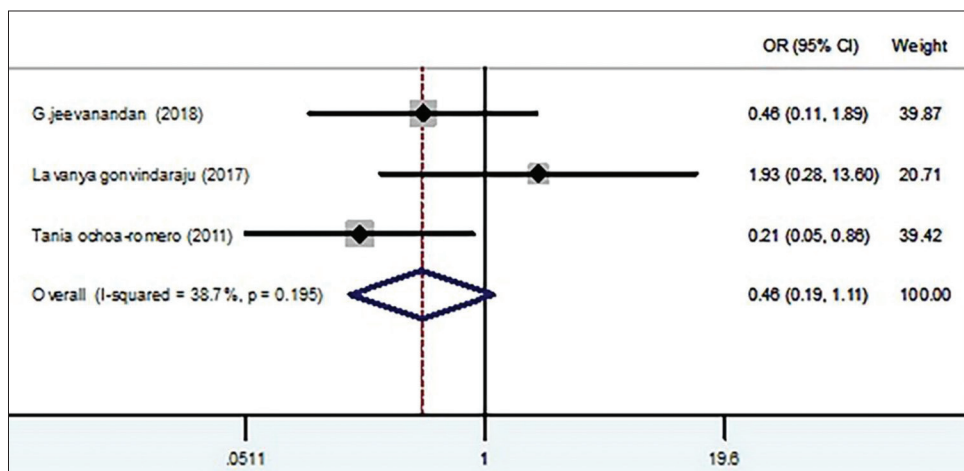


Figure 6: Forest plot based on underfilled canals

of the treatment is very essential in decreasing the anxiety among children. Shorter treatment duration decreases the anxiety, thus rendering optimal treatment protocol.^[22]

The ultimate goal of pulpectomy is to achieve good hermetic seal which depends on various factors such as good

biomechanical preparation, types of obturating material used, and achievement of good filling quality. Obturation of the canal creates a fluid-tight seal along the length of the root from the coronal opening to the apical system and eliminating all portals of entry between the periodontium

and the root canal system.^[23] An ideal technique should assure complete filling of the canal without overfill and with minimal or no voids. Confirmation of filling quality is obtained from postoperative radiograph which was assessed in all included studies in this systematic review.^[24]

All of the investigated studies except one,^[3] used Coll and Sadrian criteria for the assessment of the quality of obturation. These criteria define the root canal obturation quality as optimal fill, underfill, or overfill. Underfill means that all the canals were filled 1 mm or more short of the apex, optimal fill means that one or more canals have filling material ending at radiographic apex, and overfill means any canal showing filling material outside the root. Although the applied criteria were the same among most of the studies, only three studies^[13,14,16] had similar methodology and reporting for inclusion in the meta-analysis. Some studies compared the obturation quality based on the number of roots in each group,^[3,6,7] whereas others reported the number of teeth. This was one of the limitations for gathering the samples of all studies. The meta-analysis revealed that rotary preparation of primary tooth root canals significantly decreases the instrumentation time. With regard to obturation quality, rotary systems increase the likelihood of optimally filled teeth significantly compared to manual file, while these systems do not decrease the risk of overfilling or underfilling of primary teeth significantly.

Makarem *et al.*^[3] found a better quality of obturation only for the mesial canal of primary teeth by using rotary systems versus manual files. This result was inconsistent with the results of Govindaraju *et al.*^[6] study, in which the quality of obturation was not statistically different between the two groups in both mesial and distal canals. However, the latter study reported better obturation quality for rotary systems in mesial against distal canals which was attributed to the higher risk of overfilled obturations in large distal canals by rotary files.

Filling methods and materials as well as types of rotary systems differed between evaluated studies. ProTaper rotary system was used in three studies.^[6,15,16] Two studies applied K3 rotary file in their intervention groups.^[13,16] Mtwo rotary file,^[6] Kedo-S file,^[14] LightSpeed file,^[15] and FlexMaster system^[3,7] were other types of rotary systems that were used in the investigated studies. Manual instrumentation with K-files was used for root canal preparation in control groups of all included studies except one^[3] that used H-files.

In two studies, the obturation of root canals was done by gently pushing the filling material by cotton pellets.^[6,16] In two investigations,^[13,14] canals were filled by means of a pressure syringe, whereas Makarem *et al.*^[3] and Morankar *et al.*^[7] used Lentulo spiral in their studies. Either syringes or pluggers were applied for filling the root canals in Vieyra and Enriquez^[15] study. In four included studies,^[6,14-16] calcium hydroxide paste was used as the filling material,

while iodoform paste,^[13] a mixture of calcium hydroxide and zinc oxide,^[7] and zinc oxide-eugenol paste^[3] were other filling materials used in the investigated studies. Previous studies on the effect of filling methods on obturation quality revealed mixed results and confirmed that obturation quality can be affected by the applied filling method.^[25-27]

The diversities described above may explain the mixed results of the studies to some extent. Thereby implementation of better designed and reported interventions is highly recommended to fully assess the effectiveness of instrumentation with rotary files on obturation quality in primary teeth.

Considering the obturation time between two types of canal instrumentation methods, conflicting results were found. While Ochoa-Romero *et al.*^[13] reported a decrease in obturation time by using rotary files for canal preparation, Makarem *et al.* and Morankar *et al.*^[3,7] did not confirm this statement. Different contributing factors such as filling method and operator's experience may describe the conflicts.

In terms of quality assessment, based on Cochrane Collaboration tool for assessing the risk of bias, all included studies considered random sampling. As for allocation concealment, the data in all of the studies were not adequate, so they were found to have high risk of bias. Given the nature of the intervention, "blinding of personnel and participants" was impossible in all studies. However, all of the included studies have reported blinding of the participants and were considered to have unclear risk of bias. In five studies, the clinical outcome was evaluated with adequate blinding of the outcome assessors, so they had a low risk of detection bias. However, Ochoa-Romero *et al.*^[13] and Vieyra and Enriquez^[15] did not provide any information for blinding of the outcome assessors and had unclear risk of bias. All of the investigated studies were at low risk of attrition and reporting bias except one.^[15] Although all of the studies reported obturation quality as an outcome, we did not include the results of Vieyra and Enriquez^[15] study in this systematic review due to its high risk of reporting bias. Vieyra and Enriquez^[15] did not report the comparisons between two groups for obturation quality and did not provide sufficient and clear information about the types of primary teeth.

This systematic review and meta-analysis revealed that using rotary systems in primary tooth pulpectomy significantly decrease the instrumentation time which directly correlates with less chair time. A decreased instrumentation time reduces the child's and operator's fatigue, therefore allowing a faster treatment.^[7]

As we mentioned above, a limitation of this systematic review was the lack of clinical trials with high quality for assessment of the rotary versus manual files in primary

teeth. We suggest the conduction of better-designed trials to confirm or reject the conclusions of this systematic review.

Conclusions

Considering the limitations of this study, it can be concluded that using rotary systems for primary tooth root canal preparation decrease the instrumentation time and increase the rates of optimally filled canals. However, application of rotary files does not decrease the risk of underfilled and overfilled root canals compared to manual files. High-quality randomized controlled clinical trials are necessary before a reliable conclusion can be drawn as to the best root canal preparation method for endodontically treated deciduous teeth.

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Conflicts of interest

There are no conflicts of interest.

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