Quality of Root Canal Fillings and Procedural Errors for In Vivo Studies Prepared in Different Clinical Settings and with Rotary Systems: A Systematic Review

Background: This systematic review of the literature aimed to identify published studies and evaluate them on the quality of root canal fillings (RCF) and procedural errors with rotary systems for in vivo studies prepared for different clinical settings.

Material/Methods: A full literature exploration was conducted in Clarivate Analytics’ Web of Science, Elsevier’s Scopus, Embase, and PubMed for studies published between January 2020 and March 2024. A manual search was also performed by reviewing the references of selected papers. The following keywords were used: quality of root canal filling(s) OR quality of root canal obturation, root canal obturation OR endodontic treatment, clinical setting (academic, private, governmental), AND/OR procedural errors and rotary instrumentation.

Results: Sixteen clinical studies were included in this review. The acceptance percentages for obturation length, density, and taper were 76.3%, 74.7%, and 82.5%, respectively, indicating significantly high, good ratios. The overall RCF recorded showed that 68.2% of root canal obturations were considered acceptable. Acceptable rates remained higher than unacceptable rates in academic, hospital, and private settings, and percentages ranged from 65.2% to 93.0%. Only 5 studies reported procedural errors, namely, ledge formation, separated instruments, apical perforation, transportation, lateral perforation, and root/foramen perforation.

Conclusions: Using rotary instruments for different root canal treatment steps as instrumentation and obturations is highly recommended. Among different clinical setting and practice, these instruments resulted in a good and acceptable RCF, overall quality performed by those instruments, and few procedural errors.

Keywords: Clinical Studies as Topic • Root Canal Obturation

Full-text PDF: https://www.medscimonit.com/abstract/index/idArt/945225
Introduction

The primary goal of root canal treatment (RCT) is to prevent or address apical periodontitis; hence, it is a fundamental aspect of the field of endodontics. Within this discipline, ensuring the quality of root canal fillings (RCFs) is crucial for achieving successful outcomes and relies on the proper cleaning, shaping, and obturation of the root canals [1]. These steps are essential in preventing periapical inflammation and creating a favorable environment for healing apical inflammation. Teeth with inadequately filled root canals are more prone to periapical pathosis than are teeth with properly filled root canals [2].

In recent years, multiple studies have indicated that RCT may not be necessary in all cases of clinically diagnosed irreversible pulpitis. Less invasive treatment options, such as pulp capping and pulpotomy, have shown promising results in effectively treating pulpitis [3,4]. A recent review by León-López et al examined 74 population-based studies and found that a substantial proportion of the study population had undergone RCT, indicating its prevalence as a common therapy worldwide [5]. As a result, continuous educational programs in endodontics play a vital role in keeping practicing dentists updated with the latest advancements and ensuring adherence to appropriate endodontic guidelines to ensure the optimal technical quality of RCT [6].

The assessment of technical success in root canal obturation by the American Association of Endodontists involves the radiographic evaluation of 3 criteria: the length, taper, and density of the RCF [7]. The guidelines provided by the European Society of Endodontology state that a successful RCF should completely fill the canal without any gap or void, and it should be located 0.5 to 2 mm below the radiographic apex [7,8]. Madfa et al revealed varying percentages of the acceptable quality based on these 3 parameters and investigated their effect on the overall accepted quality [8]. If at least one of these criteria is not met, the risk of an unsuccessful RCT is remarkable, which can lead to the development or persistence of periapical pathosis [7,8].

The presence of procedural errors is an additional factor that affects the technical quality of RCFs [9-13]. According to a study conducted by Aysal et al, 76.2% of RCF teeth with procedural errors are associated with post-treatment endodontic disease and aggravate the disease [14]. These errors commonly arise from the dentist's lack of careful attention and knowledge as well as the incorrect use of hand instruments in curved canals [15]. These errors can lead to complications, such as ledge formation, which impedes instrument penetration, or instrument separation caused by stress on the instrument or manufacturing defects [16]. The American Association of Endodontists has released a case complexity assessment form to minimize the occurrence of iatrogenic errors and aid dental practitioners in managing cases within their competency or in referring advanced cases [7].

Rotary instruments are preferred over stainless steel instruments because they effectively maintain the natural curvature of the canal due to their flexibility, resulting in fewer canal shaping steps and shorter overall treatment time [17]. Rotary instruments with different taper angles provide improved coincidence, better matching the canal's anatomy than with hand instruments [18]. The use of NiTi rotary file systems enables efficient canal preparation, reducing complications such as transportation or perforations. Additionally, the frequency of procedural errors is lower when using NiTi rotary instruments for root canal shaping [9]. However, studies report a higher incidence of fractures with NiTi rotary instruments than with stainless steel instruments [16,17,19]. A combination of recent materials and equipment for RCT will result in good outcomes and minimize the failure rate [20,21].

The introduction of rotary instruments in dentistry has brought about a considerable transformation in the field. These instruments are widely used in different dental practice, and their efficacy is supported by studies conducted in academic institutes in Türkiye, Saudi Arabia, United Arab Emirates, Brazil, and South Africa [9-12,22-28]; in academic and hospital institutes conducted by Pietrzycka et al in Poland [29]; in hospitals [13,30,31] in Türkiye, Finland, and Saudi Arabia; and in private dental practices in Saudi Arabia [32].

Studies have examined the differences between manual instrumentation and rotary instruments [33,34], as well as between the shaping abilities of carved canals and outcomes of rotary instruments [35,36]. However, no systematic reviews have assessed the quality of RCFs performed using rotary instruments. Therefore, in this systematic review of the literature, we aimed to identify and evaluate published studies on the quality of root canal fillings and procedural errors with rotary systems for in vivo studies prepared for different clinical settings.

Material and Methods

Review Question

The present review was conducted following the guidelines of the Preferred Reporting Items for Systematic Review (PRISMA; www.prisma-statement.org) statement [37-39]. The Population, Intervention, Comparison, Outcome (PICO) set-up was used to frame the intensive question: “Whether quality of root canal treatments outcome in form of length, density, and taper (Intervention) used to obturate anterior, premolars, and molars teeth (Population) exhibit the same quality in all teeth.”
(Outcome) compared between studies carried out using rotary systems and different types of clinical setting as academic, hospital, and private (Comparison)."

**Selection Criteria**

The inclusion and eligibility criteria were as follows: (i) clinical studies assessing the quality of root canal treatment (obturations) of all teeth, (ii) clinical surveys measuring the quality in form of acceptable and unacceptable for at least 2 of the main 3 root canal quality parameters (length, density, and taper) and calculating the overall quality, and (iii) studies published in English. Studies performed in a phantom laboratory or on typodont teeth in the preclinical setting or using finite element analysis were excluded. Systematic reviews, case reports or series, preliminary studies, and studies published in languages other than English were also excluded.

**Literature Search**

The search was performed using combinations of Medical Subject Headings (MeSH) terms and free keywords (root canal filling, root canal filling length, root canal filling taper, root canal filling density, overall quality of root canal filling, academic, hospital, private setting, anterior teeth, premolar teeth, and molar teeth) with Boolean operators (AND, OR, and NOT) with respect to the PICO question. An electronic literature search was performed from January 2020 to March 2024, which included a librarian specialized in dental database searches operating the following records: Clarivate Analytics’ Web of Science, Elsevier’s Scopus, Embase, PubMed, and MEDLINE, without a restriction to studies published before January 2020. A manual search was then directed by checking the references of all primarily selected papers to recognize research that may have been missed during the electronic search.

**Studies Selection**

The paper collection procedure went through different steps: (i) variety based on title relevance, (ii) choice founded on abstract relevance, and (iii) full-text investigation. All texts retrieved by manual and electronic searches were collected and evaluated for inclusion according to the eligibility criteria.

**Data Extraction and Analysis**

A uniform worksheet (Microsoft Office Excel software) was used to extract the data of interest from the involved papers that were published in 2020 and onward. These data included (i) clinical studies features that included researcher(s) publication years and country where the study was conducted, numbers of canals, type of treatment setting (private, academic, hospital, or combination), and teeth type (anterior, premolar, or molar); (ii) quality of the root canal treatment obturations in relation to length, density, tapers, and the overall quality (acceptable or unacceptable) and documented as a percentage; and (iii) procedural errors that can arise during RCF and obturation of the canals (ledge, apical transportation, fractured instrument, apical perforation, and root perforation).

**Quality of Evidence**

The quality of evidence level was determined by interpretation of Grading of Recommendations, Assessment, Development, and Evaluation reference, aspects that could reduce the quality of the evidence (1 or 2 levels), cover consequences in study achievement (risk of bias), circularity of evidence, imprecision, variation of outcomes, and research unfairness. The clinical quality of the evaluated involved studies was measured by means of the boundaries of previous published relevant systematic reviews and counted clinical studies [37-39]. The overall quality of evidence level was adjusted when more than one aspect measured with an adverse effect on quality of evidence was identified and categorized as high, moderate, low, and very low [38].

**Results**

**Literature Search and Study Selection**

The primary search resulted in 929 papers. After removing 720 unrelated and matching research and titles, 209 papers were included according to the eligibility criteria. A total of 114, 18, 8, and 53 published articles were excluded. Finally, 16 published papers were selected for full-text retrieval in the present systematic review study [9-13,22-32]. These studies measured the quality of RCFs and the overall quality treatments made by different treatment practicing settings (private, academic, and hospital) for different teeth types (anterior, premolar, and molar). The PRISMA flowchart of the literature search is shown in Figure 1.

**Characteristics of Included Clinical Studies**

Figure 2 and Table 1 present the characteristics of the 16 clinical studies included: 10 were conducted in 2023 [9-11,22,23] and 2021 [13,26-28,30], 4 were published in 2022 [12,24,25,29], and a recent study was published in 2024 [32]. In relation to the study country, 8 studies were assessed in Saudi Arabia and Gulf countries [6,10,11,22,23,31], followed by 3, 2, 2, and 1 study documented in Brazil, Türkiye, Europe, and South Africa, respectively [9,12,13,22,27-29]. Most of the studies [10] were performed in academic settings [9-12,22-28] followed by 3 hospital-based studies [13,30,31]. Nine studies counted all teeth (anterior, premolar, and molar) [9,11,12,24,25,27,29-31], whereas 1 study...
Data based searched: PubMed, Medline, Elsevier’s Scopus, Embase and Clarivate Analytics Web of Science, Clinical Trials.gov.
Keyword, MeSH: Quality of root canal filling, obturation, Rotary systems, Clinical studies, maxillary teeth, mandibulat teeth.

Database searching: (n=929)
Irrelevant papers and duplicated excluded=720
Recorded screened=209
Report excluded on basis of parameters and overall=114
Full text for retrieval=95
Full text not retrieved=18
Reviews (=8)
Full text retrieved=69
Recorded excluded with specific reasons=53
Studies included=16

Figure 1. PRISMA flowchart of the literature search process.

Figure 2. Characteristics of the involved clinical studies.
<table>
<thead>
<tr>
<th>Author(s)/year/country</th>
<th>Canals number/treatment setting</th>
<th>Teeth type (%)</th>
<th>Root canal filling quality</th>
<th>Overall quality</th>
<th>Procedural errors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Length (%)</td>
<td>Procedural errors</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Accep-</td>
<td>Unaccep-</td>
<td>Accep-</td>
</tr>
<tr>
<td>Almnea R. et al, 2024/SA [31]</td>
<td>224/ Private practice</td>
<td>Molars (100%)</td>
<td>77.0%</td>
<td>23.0%</td>
<td>93.0%</td>
</tr>
<tr>
<td>Tekin et al, 2023/Türkiye [10]</td>
<td>565/ Academic</td>
<td>Anterior (29%) Premolar (21.9%) Molars (44.6%)</td>
<td>85.7%</td>
<td>14.3%</td>
<td>76.2%</td>
</tr>
<tr>
<td>Barroso et al, 2023/Brazil [21]</td>
<td>707/ Academic</td>
<td>Anterior (39.9%) Posterior (60.7%)</td>
<td>67.9%</td>
<td>32.1%</td>
<td>77.9%</td>
</tr>
<tr>
<td>Alshehri et al, 2023/SA [11]</td>
<td>278/ Academic</td>
<td>Anterior (100%)</td>
<td>85.6%</td>
<td>14.4%</td>
<td>65.1%</td>
</tr>
<tr>
<td>Ameen et al, 2023/UAE [22]</td>
<td>601/ Academic</td>
<td>Anterior (48.4%) Premolar (51.6%)</td>
<td>93.5%</td>
<td>6.5%</td>
<td>96.5%</td>
</tr>
<tr>
<td>Al Shehadat et al, 2023/UAE [12]</td>
<td>480/ Academic</td>
<td>Anterior (32.9%) Premolar (45.6%) Molars (21.5%)</td>
<td>73.5%</td>
<td>26.5%</td>
<td>57.5%</td>
</tr>
<tr>
<td>Gavini et al, 2022/Brazil [13]</td>
<td>2213/ Academic</td>
<td>Anterior (25.8%) Premolar (32.2%) Molars (42.0%)</td>
<td>72.9%</td>
<td>27.1%</td>
<td>87.3%</td>
</tr>
<tr>
<td>Mustafa, 2022/SA [23]</td>
<td>400/ Academic</td>
<td>Anterior (36.0%) Premolar (17.0%) Molars (47.0%)</td>
<td>67.3%</td>
<td>32.7%</td>
<td>51.7%</td>
</tr>
</tbody>
</table>

Table 1. Summary of included clinical studies evaluating the quality of root canal treatment.
Table 1 continued. Summary of included clinical studies evaluating the quality of root canal treatment.

<table>
<thead>
<tr>
<th>Author(s)/year/country</th>
<th>Canals number/treatment setting</th>
<th>Teeth type (%)</th>
<th>Root canal filling quality</th>
<th>Overall quality</th>
<th>Procedural errors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Length (%)</td>
<td>Density (%)</td>
<td>Taper (%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Acceptable Unacceptable</td>
<td>Acceptable Unacceptable</td>
<td>Acceptable Unacceptable</td>
</tr>
<tr>
<td>Javed et al, 2022/SA [24]</td>
<td>653/ Academic</td>
<td>Anterior (38.0%) Premolar (36.5%) Molars (25.5%)</td>
<td>86.2% 13.8%</td>
<td>89.0% 11.0%</td>
<td>94.0% 6.0%</td>
</tr>
<tr>
<td>Pietrzycka et al, 2022/Poland [28]</td>
<td>1733/ Academic &amp; Hospital</td>
<td>Anterior (38.8%) Premolar (25.9%) Molars (35.3%)</td>
<td>81.5% 18.5%</td>
<td>98.0% 2.0%</td>
<td>NM NM</td>
</tr>
<tr>
<td>İnce Yusufoglu et al, 2021/Türkiye [14]</td>
<td>3115/ Hospital</td>
<td>Molars (100%)</td>
<td>79.5% 20.5%</td>
<td>49.6% 50.4%</td>
<td>58.8% 41.2%</td>
</tr>
<tr>
<td>Agwan et al, 2021/SA [25]</td>
<td>170/ Academic</td>
<td>Anterior (18.2%) Posterior (81.8%)</td>
<td>59.5% 40.5%</td>
<td>61.5% 38.5%</td>
<td>36.0% 64.0%</td>
</tr>
<tr>
<td>Fritz et al, 2021/Brazil [27]</td>
<td>442/ Academic</td>
<td>Anterior (45.9%) Premolar (54.1%)</td>
<td>96.6% 3.4%</td>
<td>97.0% 3.0%</td>
<td>NM NM</td>
</tr>
<tr>
<td>Laukkannen et al, 2021/Finland [29]</td>
<td>426/ Hospital</td>
<td>Anterior (34.2%) Premolar (40.7%) Molars (25.1%)</td>
<td>57.0% 43.0%</td>
<td>61.5% 38.5%</td>
<td>NM NM</td>
</tr>
<tr>
<td>Patel et al, 2021/South Africa [26]</td>
<td>NM/ Academic</td>
<td>Anterior (51.2%) Premolar (20.4%) Molars (28.4%)</td>
<td>68.9% 31.1%</td>
<td>73.6% 26.4%</td>
<td>70.9% 29.1%</td>
</tr>
<tr>
<td>Al-Obaida et al, 2020/SA [30]</td>
<td>400/ Hospital</td>
<td>Anterior (28.5%) Premolar (30.7%) Molars (41.0%)</td>
<td>51.5% 48.5%</td>
<td>62.5% 37.5%</td>
<td>65.7% 34.3%</td>
</tr>
</tbody>
</table>

SA – Saudi Arabia; UAE – United Arab Emirates; NM – nonmentioned; Max – maxillary; Mand – mandibular.
examined anterior teeth [10], and 2 studies investigated the RCF quality in molars (14,31). The total number of the treated canals in the 16 clinical studies was 12,407. The highest number of obturated roots was 3115 canals by Ince Yusufoglu et al (Türkiye) [13], followed by 2213 canals by Gavini et al in Brazil [12]; the lowest numbers of RCFs were in studies conducted in Saudi Arabia by Agwan et al and Almnea, with 170 and 240 canals, respectively [26,32]. One study, conducted in South Africa, did not mention the number of treated canals [27].

Root Canal Filling and Overall Quality Outcomes

Figure 3 reveals that the acceptance percentages were much higher than the unacceptable percentages of root canal obturation quality (length, density, and taper) in all clinical studies. The percentages of acceptable percentage in relation to the length, density, and taper of obturated canals were 76.3%, 74.7%, and 82.5%, respectively. The overall acceptable quality of root canal obturations were almost two-thirds of the unacceptable ratio and accounted 68.2% for the included studies. Figure 4 shows that the acceptance percentages were much higher than the unacceptable percentages of root canal obturation quality (length, density, and taper) in academic, hospital, and private settings. The percentages of acceptable percentage in relation to the RCF length of treated canals were 76.1%, 67.5%, and 77.0%, to density of treated canals were 75.7%, 68.0%, and 93.0%, and to taper of treated canals were 73.8%, 62.3%, and 91.0%. The overall acceptable quality of RCFs was much higher in different treatment settings (65.2%, 64.5%, and 87.0%).

Procedural Errors During Treatments

Of the 16 clinical studies, 5 reported a procedural error in ledger, 4 noted separated instruments [9-11,13], 3 recorded...
### Table 2. Results of bias analysis among the selected studies.

<table>
<thead>
<tr>
<th>Author (s)/year/country</th>
<th>Title</th>
<th>Objective</th>
<th>Eligibility criteria</th>
<th>Information sources</th>
<th>Risk of bias</th>
<th>Included studies</th>
<th>Synthesis of results</th>
<th>Limitations of evidence</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almnea, 2024/SA [31]</td>
<td>√</td>
<td>√</td>
<td>X</td>
<td>–</td>
<td>√</td>
<td>√</td>
<td>X</td>
<td>–</td>
<td>√</td>
</tr>
<tr>
<td>Barroso et al, 2023/Brazil [21]</td>
<td>√</td>
<td>√</td>
<td>X</td>
<td>X</td>
<td>–</td>
<td>√</td>
<td>X</td>
<td>–</td>
<td>√</td>
</tr>
<tr>
<td>Ameen et al, 2023/UAE [22]</td>
<td>√</td>
<td>√</td>
<td>X</td>
<td>X</td>
<td>–</td>
<td>√</td>
<td>X</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Al Shehadat et al, 2023/UAE [12]</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>X</td>
<td>–</td>
<td>√</td>
<td>–</td>
<td>√</td>
<td>–</td>
</tr>
<tr>
<td>Gavini et al, 2022/Brazil [13]</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>X</td>
<td>–</td>
<td>√</td>
<td>–</td>
<td>√</td>
<td>–</td>
</tr>
<tr>
<td>Mustafa A 2022/SA [23]</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Javed et al, 2022/SA [24]</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>X</td>
<td>–</td>
<td>√</td>
<td>–</td>
<td>√</td>
<td>–</td>
</tr>
<tr>
<td>Pietrzycka et al, 2022/Poland [28]</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>–</td>
<td>√</td>
<td>√</td>
<td>–</td>
<td>√</td>
<td>–</td>
</tr>
<tr>
<td>Fritz et al, 2021/Brazil [27]</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>X</td>
<td>–</td>
<td>√</td>
<td>X</td>
<td>–</td>
<td>√</td>
</tr>
<tr>
<td>Laukkonen et al, 2021/Finland [29]</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>X</td>
<td>–</td>
<td>√</td>
<td>–</td>
<td>√</td>
<td>X</td>
</tr>
</tbody>
</table>

Where √ (low); – (neutral); X (high). SA – Saudi Arabia; UAE – United Arab Emirates.
apical perforation and transportation [9-10,13], 2 recorded lateral perforation and transportation [9,11], and 1 recorded root and foramen perforation [10].

**Results of Bias Assessment**

Overall, most of the clinical studies analyzed in the current systematic review had a moderate to high risk of bias and were conducted in clinical, academic, hospital, and private settings, except those studies that recorded low-grade risk bias and were assessed in Brazil, Poland, Finland, and Saudi Arabia [12,29,30,32], as shown in Table 2.

**Discussion**

The outcome of RCT greatly depends on the quality of root canal obturation, especially in cases in which the complete reduction of bacterial load is not feasible. Achieving a successful endodontic therapy often involves filling the root canal within 2 mm of the radiographic apex, ensuring homogeneity without any gap [8]. In the past 3 decades, the introduction of rotary NiTi files has remarkably enhanced the efficiency and quality of shaping procedures and facilitated faster, more convenient instrumentation, resulting in improved preservation of the canal center and reduced procedural errors [9]. In this review, we aimed to assess the quality of RCFs performed using rotary instruments and to determine the percentage of procedural errors in different clinical settings.

The findings of the study demonstrated a remarkably higher occurrence of root fillings with acceptable technical quality, reaching a frequency of 68.2% with fewer procedural errors, and included studies performed by different clinical settings by using rotary instruments in studies published after 2020. This percentage was notably better than the 48.75% with more procedural errors reported by Ribeiro et al [40]; however, their report was limited to studies conducted among undergraduate students by using hand instrumentation and those carried out before 2015 [40]. Consistent with the present study, Burns et al found that technological advancements in root canal instrumentation, for example, NiTi rotary instruments, increase the efficiency and reproducibility of endodontic treatment [38].

The frequency of acceptable root fillings varied across different settings. In the academic setting, the range was from 38.1% by Al Shehadat et al [11] to 93.8% by Friz et al [28]. In the hospital setting, the frequency ranged from 41.2% by Ince Yusufoglu et al [13] to 67.4% by Laukkanen et al [30]. The private setting achieved an overall frequency of 87.0% among all the included studies. These frequencies in this review can be attributed to the practices of hospital dental practitioners who accept a wide range of cases in their clinics before referring them to specialists. Dental students in universities perform dental services under strict supervision from faculty staff during clinical exposure [41]. During their clinical years, students follow meticulously designed rubrics for each step of RCF procedures. These procedures are closely supervised by faculty members to ensure optimal outcomes at each stage of the treatment plan [41].

The length of RCFs substantially influences the treatment outcomes and is determined by measuring the apical terminus of the obturation on postoperative radiographs. Multiple studies [9-11,13] have consistently identified length as the most commonly achieved parameter. Insufficient length of the condensed obturation material can lead to endodontic treatment failure due to microbial activity and byproduct accumulation. Prior studies have demonstrated that using an apex locator alongside radiographs improves length control, preventing the formation of empty spaces in the apical region that could facilitate bacterial colonization resulting from underfilling [29,32]. Conversely, overfilling occurs when the root canal material extends beyond the apical foramen, which is associated with reduced prognosis for RCT and potential infections in the intra- and/or extra-radicular area [27].

The association between density and treatment prognosis remains unclear. Kirkevang et al discovered that the presence of voids in RCFs considerably influences the incidence of apical periodontitis [42]. Hommez et al observed that nonhomogeneous RCFs have a 47.1% incidence of apical periodontitis, compared with homogeneous RCFs, with 27.7% [43]. This result suggests that less dense, nonhomogeneous RCFs are more likely to exert a negative influence on the treatment outcomes. Among the studies reviewed, 7 reported that achieving high density in RCFs is associated with better outcomes [22,26-30,32]. Inadequate RCFs with voids were particularly vulnerable to bacterial leakage, leading to apical periodontitis. Certain areas of the root canal system, such as ramifications, dentin tubules, and the apical delta, can remain inaccessible to endodontic instrumentation, irrigation, and medication, enabling the presence of residual bacterial debris [44].

The taper should ideally provide a smooth transition from the wider coronal area to the narrower apical area, mimicking the natural shape of the canal [27]. Rotary instruments, with their varied taper angles, offer improved conicity to the existing canal anatomy, compared with hand instruments [9]. Five studies demonstrated that the taper of the RCF was most frequently recorded among the different parameters [12,23,24]. Posterior teeth were mostly treated in many studies [9,11-13,22,24,26,32] despite the presence of complex anatomy of these teeth, which are usually associated with narrow and curved canals that require a large amount of time and patience to clean, shape, and obturate properly [9]. The use of NiTi rotary instruments,
known for their exceptional elasticity and advanced design, has proven advantageous in effectively maintaining the curvature of narrow and curved root canals [16].

Procedural errors are an important factor for the long-term success of endodontically treated teeth [14]. Therefore, the detection of procedural errors, such as instrument fractures, ledge-zip formations, and perforations, might cause the failure of nonsurgical RCT. Concurrently, procedural errors in the cleaning and preparation of the root canal have a negative effect on the success of the RCT, by providing inadequate chemo mechanical preparation and obturation of the root canals [16]. The presence of ledges and separated instruments has been reported in only 4 studies [9-11,13], and these errors can hinder the control of endodontic infection by obstructing access to the apical terminus [9]. Although rotary files have a higher likelihood of file fracture than manual files, the occurrence of ledge formation and canal transportation is lower when using NiTi rotary files, specifically when compared with manual stainless steel files [16,17,19]. Recently, a high percentage of procedural errors was observed in a study conducted in China, and an improvement in the technical quality of endodontic treatment was recommended [14].

The present systematic review of clinical studies encountered substantial limitations. First, few studies evaluated the procedural errors, and a notable variation was observed in the methodologies employed among the studies included. Second, a majority of the studies were classified as having a “high to moderate” bias in terms of quality. Third, discrepancies in the dimensions, including the length, width, curvature, and number of roots of the anterior, premolar, and molar teeth, among the included studies may have influenced the assessment of acceptable and unacceptable quality of RCFs. Consequently, these limitations may have influenced the overall evaluation of RCF quality in the countries where the studies were conducted.

Conclusions

The findings of this research suggest that the use of technological advancements, such as NiTi rotary instruments, during root canal fillings in different clinical settings is an acceptable term of the 3 parameters (length, density, and taper) and is associated with few procedural errors.

Department and Institution Where Work Was Done

This work was carried out at the College of Dentistry, Jazan University, Saudi Arabia.

Declaration of figures’ Authenticity

All figures submitted have been created by the authors, who confirm that the images are original with no duplication and have not been previously published in whole or in part.

References:


