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Comparison of The Success Rates of Different Endodontic Obturation Techniques Based on A Clinical and Radiological Assessment

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Abstract

Background: To avoid reinfection and encourage apical healing, the endodontic system must be sufficiently sealed following appropriate chemo-mechanical preparation. As a result, numerous obturation methods and materials have been created.

Aim: Comparison of the success rates of three different endodontic obturation techniques based on a clinical and radiological follow up and to evaluate the effects of various tooth- and patient-related factors on the endodontic outcome.

Methods and materials: This clinical study investigated the endodontic outcome of 228 teeth treated between the years 2022 and 2025. Three different obturation methods were used: (1) adhesive obturation using the continuous wave of condensation technique with Resilon® (CWR), (2) matching-taper single-cone technique with gutta-percha and AH Plus® (SCGP), and (3) matching-taper single-cone technique with gutta-percha and GuttaFlow® (SCGF). Pre- and postoperative periapical radiographs were performed to detect the presence of endodontic lesions (PAI classification) and to assess the quality of both the obturation and the restoration. Tooth- and patient-related data were collected.

Result: The overall endodontic success rate was 75.4% after a mean observation period of 6.3 years. There were no significant correlations between the type or overall quality of obturation and the treatment outcome. Teeth with preoperative lesions had the highest odds ratio (factor of 4.98) for endodontic failure. Tooth- and patient-related variables had no significant effect on endodontic outcome.

Conclusion: The preoperative periapical status of teeth requiring endodontic treatment was a substantial prognostic factor for endodontic outcome, whereas the type of obturation material or technique did not affect it.

Keywords: Obturation technique, success, endodontics

Introduction

Tooth preservation depends on effective endodontic therapy. The quality of endodontic treatment has increased because to significant advancements in materials and techniques over the past few decades. Still, there is room for improvement.[1,2] Completely accessing the endodontic system, cleaning the dentin, and sealing the entire endodontic space are the goals of root canal therapy. To avoid reinfection and encourage apical healing, the endodontic system must be sufficiently sealed following appropriate chemo-mechanical preparation. As a result, numerous obturation methods and materials have been created.[3,4]

In order to compensate for imperfections in the prepared root canal and seal the dentinal tubules, ramifications, and ancillary root canals, a root canal filling typically consists of a core material (often gutta-percha) and a low-viscosity sealing substance (sealer).[5] Since most sealers are soluble in liquids and undergo dimensional changes when setting, it is best to apply as little sealer as possible.[6] Cold lateral compaction was regarded as a typical method in endodontic obturation in numerous research. It is a safe, reliable, and economical obturation method with positive long-term outcomes.[7-9]

But cold lateral compaction is also known to be challenging and prone to mistakes, and it is especially vulnerable to voids, underfilling of curved root canals, and vertical root fractures brought on by applying excessive compaction forces.[10-12] Matching-taper single-cone obturation was introduced as a straightforward substitute. Accessory cones are not required when using a tapered gutta-percha master cone that matches the final shaping file. It was discovered that this approach yielded outcomes similar to those of the cold lateral compaction method.[13,14] However, because root canals are rarely round, only sealer is used to cover the areas next to the prepared round channels, which could result in less dense root canal fillings than with other methods. The sealer is crucial in this situation.[15]

According to reports, epoxy-resin-based sealers such as AH Plus® (Dentsply Sirona, Charlotte, NC, USA) set the standard for root filling products.[16,17] A silicone-based non-resorbable sealer (GuttaFlow®, Coltène/Whaledent AG, Altstös, Switzerland) was created to make root canal filling even easier. Gutta-percha particles and a polydimethylsiloxane-based sealer make up this cold, flowable, self-curing obturation substance. After applying GuttaFlow® straight into the root canal, a gutta-percha master cone is inserted to compact the material.

This achieves good material flow into the undercuts and lateral canals but has been associated with a high risk for extrusion of the material into the periapical tissue.[18,19] GuttaFlow® expands slightly during the setting process and, in contrast to AH Plus®, is almost insoluble in tissue fluids. Thus, a higher amount of sealer must be applied in order to obtain an adequate obturation and may lead to a higher sealing capacity.[20-22]

The adhesive root canal filling substance Resilon® was another innovation to enhance the root canal system's sealing. This synthetic and thermoplastic polymer (polycaprolactone), when combined with a self-conditioning and dual-curing methacrylate-based sealer, was designed to provide an adhesive bind to both the root dentin and the sealer in accordance with the

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adhesive approach in restorative dentistry.[23] Theoretically, this produces a "monoblock," which ought to provide a very dense obturation. However, due to the inadequate cavity configuration factor (C-factor) and the unattractive geometric shape of root canals, this idea was evaluated severely.[24]

Adhesive technology was thought to have serious limits in terms of material stress and gap creation caused by shrinkage processes both before and after polymerization, as well as biodegradation of the material brought on by bacterial hydrolases. When compared to lateral condensation of gutta-percha using AH Plus®, certain in vitro investigations revealed less leakage in root canal fillings using Resilon® and GuttaFlow®.[21,22] Nevertheless, there is a dearth of long-term clinical outcome data for root canals filled with GuttaFlow®, a silicone-based sealer. Two long-term clinical trials have demonstrated a 5.3- to 5.7-fold increased risk of failure for root-canal-treated teeth obturated with Resilon® as opposed to those obturated with gutta-percha and AH Plus®.[23,24]

Resilon® was linked to a higher rate of deterioration than gutta-percha and sealer, according to an observational study evaluating the deteriorated filling material of non-healed cases necessitating retreatment.[21-23]

The objective of the present study was to determine the success rates of three different endodontic obturation techniques based on a clinical and radiological follow up and to evaluate the effects of various tooth- and patient-related factors on the endodontic outcome. The null hypothesis stated that there is no significant difference in treatment outcome between the three root canal obturation techniques evaluated in this study.

Materials and Methods

Patients were asked to take part in this study if their teeth met all the requirements for inclusion. The patient's incomplete records, lack of legal age, incapacity to conduct a clinical evaluation, unwillingness to engage in the study, or death were the exclusion criteria. The necessary clinical and radiologic follow-up examination was performed on 238 individuals, involving 262 teeth. 21.1% (238/1130) was the recall rate. To lessen the impact of patient-specific confounding factors, the statistical analysis only included one tooth per study participant. As a result, there were 228 cases in total, with each study participant having one assessed tooth. uniform endodontic techniques, such as uniform chemo-mechanical preparation and irrigation regimens, were used for all root canal treatments.

A working length radiograph was used to confirm the working length, which was established using an apex finder. The ideal working length distance from the radiography apex was between 0.5 and 1.0 mm. Nickel-titanium rotary files (Mtwo®, VDW) were used to prepare the root canal system after the root canals were scouted and a glide path was shaped. Most of the time, the apical preparation size was ISO 40/.04. In every instance, irrigation was done using a 5% sodium hypochlorite solution.

Root canal obturation was performed using three different obturation techniques:

- Adhesive obturation using the continuous wave of condensation technique with Resilon® (CWR).
- Matching-taper single-cone obturation with gutta-percha and the epoxy-resin-based sealer AH Plus® (SCGP).

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- Matching-taper single-cone obturation with gutta-percha and the silicon-based sealer GuttaFlow® (SCGF) .

For the adhesive obturation technique, a master cone (RealSeal™, SybronEndo Europe, Amersfoort, The Netherlands) was adjusted to have tug-back 1 mm before working length. The canals were irrigated with an ethylene-diamine-tetra-acetic acid (EDTA) solution and dried with paper points. The primer (RealSeal™, SybronEndo Europe, Amersfoort, The Netherlands) was applied for 30 s. After removing excess material with the paper points, the master cone was thinly coated with the sealer (RealSeal™, SybronEndo Europe, Amersfoort, The Netherlands) and inserted into the root canal. A heat plugger (System B™, Heat Source, SybronEndo Europe, Amersfoort, The Netherlands) was used to create a down-pack of 3 to 5 mm before the working length. The back-fill was performed using heated Resilon®-Pellets (RealSeal™, SybronEndo Europe, Amersfoort, The Netherlands) in a gutta-percha gun (Obtura II™, Obtura Spartan Endodontics, Algonquin IL, USA) for a subsequent vertical obturation (continuous wave of condensation technique) of 4 to 5 mm increments.

For single-cone obturation with an epoxy-resin-based sealer (AH Plus®, Dentsply Sirona) a matching-taper gutta-percha cone was adjusted to the root canal, having tug-back at the working length. The master cone was thinly coated with AH Plus® and inserted into the root canal.

For single-cone obturation with a silicon-based sealer (GuttaFlow®, Coltène/Whaledent GmbH + Co. KG, Langenau) a matching-taper gutta-percha cone was adjusted to the root canal, having tug-back at the working length. GuttaFlow® was injected into the root canal first (adjusted 3 mm before working length), and the master cone wetted with GuttaFlow® was set in afterward.

The teeth were restored with partial or full crowns or regular composite fillings. Radiographic documentation was performed using digital radiographs (VistaScan Mini View, Duerr Dental SE, Bietigheim-Bissing, Germany) or conventional 30 × 40 mm intraoral radiographs (Insight, Kodak). The conventional radiographs were digitized to the highest quality possible for study evaluation.

One of the authors conducted the follow-up examination after an average of 6.26 years (minimum 4.65, maximum 8.68 years). Every patient was asked about periodontitis, inhalative tobacco use throughout pack years, and use of chronic disease medications (CDM, such as those for diabetes, hypertension, and hyperlipidemia). Every patient had radiological and clinical examinations. The periodontal screening index (PSI), tooth mobility, and dental state were evaluated. Lastly, digital radiographs (Heliodent® DS, Sirona Dental Systems GmbH, Bensheim, Germany; VistaScan Mini View, Duerr Dental SE, Bietigheim-Bissing, Germany) were used for the radiological follow-up.

Two senior endodontists with at least ten years of experience conducted all radiologic evaluations. The periapical state of the teeth was evaluated using PAI scores following the calibration of both examiners using a collection of 100 reference radiographs linked to the PAI system. Additionally assessed were the coronal restorations' quality and the length and uniformity of root canal fills. Teeth were categorized as successes if their PAI score was 1 or 2, and as failures if their PAI value was 3 or above.

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Statistical analysis

SPSS® Statistics (IBM, version 25.0) was used to conduct statistical analyses. The statistical analysis used t-tests, Fisher's exact test, and Chi-square tests with Yates continuity correction. The effect size was measured using Cramer's V and Phi φ. The link between the ratio of a possible risk factor and the ratio of a disease's occurrence was measured using the odds ratio (OR). The significance level was established at $\alpha = 0.05$. Cohen's kappa coefficients were used to evaluate the inter-rater reliability of assessing PAI scores at both calibration and data collection. The odds ratio in the presence of several explanatory variables was obtained using logistic regression.

Results

This study included 228 teeth from 238 patients, whose average age was 61 years (SD: 16.9 years). The recall interval ranged from 4.7 to 8.8 years, with a mean of 6.4 years. Prior to treatment, 142 teeth had a periapical lesion (PAI score of 3–5) and 86 teeth had a healthy or sound periapical condition (PAI score of 1-2). Following the procedure, 56 teeth had an apical lesion and 172 teeth were periapically healthy, resulting in a 75.4% endodontic success rate. At baseline and during the control period, the inter-rater reliability (kappa coefficients) for the agreement of PAI scores between the two investigators was 0.85 and 0.95, respectively, indicating a strong to almost perfect agreement.

Table 1: Periapical status of root-canal-treated teeth before and after treatment.

	Total [*n*]	Sound [*n*] (%)	Diseased [*n*] (%)
Before intervention	228	86 (37.8%)	142 (62.4%)
After intervention	228	172 (75.5%)	56 (24.7%)

n = sample size.

The success rates were 85% for SCGP (68/80) compared to 80% (16/20) for SCGF and 68.7% (88/128) for CWR. The chi-square test for independence showed no statistically significant relationship between the success rate and the various obturation techniques ($\mathcal{X}2(2, n = 228) = 3.63, p = 0.16$).

Table 2: Success and failure rates by obturation technique.

Obturation Technique	Total [*n*] (%)	Success [*n*] (%)	Failure [*n*] (%)
CWR	128 (56.1%)	88 (68.7%)	40 (31.3%)
SCGP	80 (35.1%)	68 (85.0%)	12 (15.0%)
SCGF	20 (8.8%)	16 (80.0%)	4 (20.0%)
Total [*n*]	228 (100%)	172 (75.4%)	56 (24.6%)

n = sample size.

The chosen obturation technique had no bearing on the obturation's homogeneity (p = 0.2) or the root filling material's extrusion into the periapical tissues (p = 0.93). There was a significant difference in the root canal filling length between the groups (p = 0.04*). When compared to SCGF and CWR, the SCGP procedure produced the greatest percentage of acceptable root canal fills. The largest percentage of under filled obturations was found using the CWR approach.

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Table 3: Quality of RCF depending on the obturation technique.

Quality Criteria		CWR (n = 64)	SCGP (n = 40)	SCGF (n = 10)	p	Effect Size
Homogeneity	Homogeneous	102 (79.7%)	54 (67.5%)	18 (90.0%)	0.20	
	Inhomogeneous	52 (20.3%)	52 (32.5%)	2 (10.0%)		
Extrusion of RCF	No extrusion	108 (84.4%)	66 (82.5%)	16 (80.0%)	0.93	
	Extrusion	20 (15.6%)	14 (17.5%)	4 (20.0%)		
Length of RCF	Adequate	92 (71.9%)	74 (92.5%)	16 (80.0%)	0.04 *	0.24 (Cramer's V)
	Underfilled	24 (18.7%)	6 (7.5%)	0 (0.0%)		
	Overfilled	12 (9.4%)	0 (0.0%)	4 (20.0%)		

n = sample size; *p* = significance value using chi-square test; * = significant, $p \leq 0.05$.

The endodontic outcome was generally unaffected by the quality of the root canal fillings. The variables obturation length ($p = 0.12$) and homogeneity ($p = 0.11$) as well as the extrusion of root filling material into the periapical region ($p = 1.00$) showed no significant influence on the endodontic outcome. The patient-related variables age ($p = 0.45$), gender ($p = 0.67$), periodontitis ($p = 0.08$), CDM ($p = 0.19$), recall interval ($p = 0.08$), and smoking ($p = 0.34$) showed no significant influence on the endodontic outcome. There was no significant difference in success rates between retreatments (70.5%, 62/88) and primary treatments (78.6%, 110/140; $p = 0.45$). In teeth with a preoperative apical lesion, the success rate was 66.2% (94/142) compared to 90.7% ($n = 78/86$) in cases without an apical lesion ($p = 0.007$). The probability of failure in the presence of a preoperative lesion was increased by a factor of 4.98 (OR = 4.98, 95% CI: 1.60, 15.57, $p = 0.006$). With regard to tooth type, molars were more frequently represented with 64 cases than incisors and premolars with 25 cases each. Interestingly, molars had a higher failure rate, but there was no significant correlation between tooth type and endodontic outcome ($p = 0.07$).

Discussion

The current study's objective was to assess, using a maximally standardized data pool, the success rate of endodontic therapy by root canal filling material and technique. According to the null hypothesis, the three root canal obturation methods (CWR, SCGP, and SCGF) assessed in this study do not significantly differ in treatment outcomes. It is possible to prove the null hypothesis. Neither the obturation method nor the obturation materials significantly affected the long-term endodontic outcome at a mean recall interval of 6.3 years. In 114 cases, the success percentage across all groups was 75.4%. Similar success rates ranging from 68% to 85% have been observed in other endodontic outcome studies.[24,25]

According to the current study, SCGP has the best success rate (85%), followed by CWR (68.7%) and SCGF (80%). However, the obturation technique and treatment outcome did not show a statistically significant association. Root canals filled with Resilon® (38 of 90 teeth in the CWR group) showed a tendency toward a higher rate of non-healing of preoperative periapical

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lesions than those filled with gutta-percha and AH Plus® (4 of 21 teeth in the SCGP) or gutta-percha and GuttaFlow® (1 of 5 teeth in the SCGF). There was no discernible difference in the success rates between the two groups in a similar clinical investigation of 103 root-canal-treated teeth filled with either Resilon® or gutta-percha and AH Plus® [39]. The recall interval, however, was extremely brief (≤24 months).[21,22]

Resilon® had a success rate of just 56%, while gutta-percha and AH Plus® had an 88% success rate, according to a long-term observational research with a mean follow-up of 5.8 years.[21,22] Compared to gutta-percha, Resilon® showed a far increased chance of endodontic failure (OR = 5.7). Lower endodontic success rates following adhesive obturation with Resilon® were also seen in a clinical investigation involving 125 teeth.[23] It was determined that Resilon® may result in a worse long-term endodontic outcome than gutta-percha and AH Plus® due to the 5.3-fold increased risk of an endodontic lesion following root canal therapy. Compared to the current study (6.3 years), the mean follow-up interval (12.4 years for Resilon® fillings and 12.1 years for gutta-percha fillings) was noticeably longer.

The authors explained how the greater failure rate of Resilon® could be attributed to the significant danger of bacterially driven biodegradation of the obturation substance [40]. The current study's observation period might have been too little to show a detrimental effect of the Resilon® material's biodegradation.[21-24]

In the present study, the group of root-canal-treated teeth obturated with gutta-percha and the silicone-based sealer GuttaFlow® (SCGF) contained a very small number of cases (*n* = 10). The success rate of SCGF appeared to be comparable to that of the other two techniques. Numerous in vitro studies on the physicochemical properties, marginal adaptation characteristics, and bacterial leakage resistance of GuttaFlow® suggest that this material is associated with a clinically promising endodontic outcome[18-21]. However, comprehensive clinical studies quantifying the success rates of root canal treatment with GuttaFlow® are currently lacking. Therefore, randomized controlled trials are needed.

All primary endodontic treatments and retreatments were performed by four experienced endodontists with at least three years of training in endodontics. In addition, all operators worked at our teaching hospital and followed standardized chemo-mechanical preparation and irrigation protocols during all root canal treatments.

In this study, conventional root filling materials were investigated. Modern endodontic materials such as bioceramic or bioactive sealers have been introduced recently. However, to date, their supposed more favorable results in periapical healing have low evidential support[24].

A severe limitation of the present study is the low recall rate of 21.1%. Several reasons must be considered for not recording 446 of 565 root-canal-treated teeth in the defined observation period of four years. There was incomplete documentation in 34.0% of the cases, no response from the patient in 19.5% of the cases, evident tooth extraction in 11.0% of the cases, and various other reasons in 14.5% of the cases. However, great efforts were made to keep the sample size for recall as large as possible, in particular by carefully reviewing all data available at the dental clinic. Most of the included patients attend the clinic for general dental care.

Assessment of the technical quality criteria revealed that the studied root canal filling groups differed significantly in terms of filling length. The percentage of

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underfilled canals was significantly higher with CWR compared with SCGP or SCGF. In contrast, another clinical study found no difference in radiographic obturation length between the continuous wave of condensation technique (n = 180) and the single-cone technique (n = 160).[23,24] The ability of CWR to achieve an adequate length of root filling may be limited by the need to adjust the master point according to the verified working length. In the CWR group, the tip of the gutta-percha point was generally set 1 mm short of the working length to prevent extrusion of the root filling material during the vertical compaction phase. It was reported that the vertical obturation technique with warm gutta-percha may be associated with an increased incidence of overextension.[16] In the present study, there were no significant differences in the extrusion of root filling material between the groups, and the success rate of endodontic treatment was not significantly affected by any of the quality criteria (length, homogeneity, extrusion of RCF). However, a correlation between the length of the root canal filling and the endodontic outcome has been observed in other studies.[17] Consistent with numerous studies, we found that the preoperative periapical condition was the most important prognostic factor (OR = 4.98) for the success or failure of root canal treatment.[21,22] Within the limitations of this retrospective study, tooth- and patient-related variables (the so-called secondary outcome factors) can be considered as having minor relevance and effect on the endodontic outcome. In accordance with the clinical study of Jahreis, et al, there was no significant correlation between CDM and the endodontic outcome, at least highlighted in a population of 60 years. However, the results of a prospective study indicate that several patient- and tooth-related variables (e.g., diabetes, pathological periodontal probing depths, or lower molars in terms of tooth type) may be associated with a higher risk for tooth loss or endodontic failure.[21-25]

Conclusion

The preoperative periapical state of teeth that require endodontic treatment is a significant predictor of endodontic outcome, while the kind of obturation material or technique had no effect on endodontic outcome, according to the study's limitations.

References

1. Tay F.R., Loushine R.J., Lambrechts P., Weller R.N., Pashley D.H. Geometric factors affecting dentin bonding in root canals: A theoretical modeling approach. J. Endod. 2005; 31:584–589. doi: 10.1097/01.don.0000168891. 23486.de. [DOI] [PubMed] [Google Scholar]
2. De Munck J., Van Landuyt K., Peumans M., Poitevin A., Lambrechts P., Braem M., Van Meerbeek B. A critical review of the durability of adhesion to tooth tissue: Methods and results. J. Dent. Res. 2005; 84:118–132. doi: 10.1177/ 154405910508400204. [DOI] [PubMed] [Google Scholar]
3. Kim Y.K., Grandini S., Ames J.M., Gu L.S., Kim S.K., Pashley D.H., Gutmann J.L., Tay F.R. Critical review on methacrylate resin-based root canal sealers. J. Endod. 2010; 36:383–399. doi: 10.1016/ j. joen.2009.10.023. [DOI] [PubMed] [Google Scholar]
4. Kqiku L., Miletic I., Gruber H.J., Anic I., Städtler P. Microleakage of root canal fillings with GuttaFlow and Resilon compared with lateral condensation. Wien. Med. Wochenschr. 2010; 160:230–234. doi: 10.1007/s10354-010-0790-5. [DOI] [PubMed] [Google Scholar]

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5. Prithviraj K.J., Manjunatha R.K., Horatti P., Rao N., Gokul S. In Vitro comparison of the microbial leakage of obturation systems: Epiphany with resilon, guttaflow, and ah plus with gutta percha. Indian J. Dent. Res. Off. Publ. Indian Soc. Dent. Res. 2020; 31:37–41. doi: 10.4103/ijdr.IJDR_98_18. [DOI] [PubMed] [Google Scholar]
6. Barborka B.J., Woodmansey K.F., Glickman G.N., Schneiderman E., He J. Long-term Clinical Outcome of Teeth Obturated with Resilon. J. Endod. 2017; 43:556–560. doi: 10.1016/j.joen.2016.12.005. [DOI] [PubMed] [Google Scholar]
7. Strange K.A., Tawil P.Z., Phillips C., Walia H.D., Fouad A.F. Long-term Outcomes of Endodontic Treatment Performed with Resilon/Epiphany. J. Endod. 2019; 45:507–512. doi: 10.1016/ j.joen. 2019.01.019. [DOI] [PubMed] [Google Scholar]
8. Payne L.A., Tawil P.Z., Phillips C., Fouad A.F. Resilon: Assessment of Degraded Filling Material in Nonhealed Cases. J. Endod. 2019; 45:691–695. doi: 10.1016/j.joen.2019.02.019. [DOI] [PubMed] [Google Scholar]
9. Pirani C., Camilleri J. Effectiveness of root canal filling materials and techniques for treatment of apical periodontitis: A systematic review. Int. Endod. J. 2022 doi: 10.1111/iej.13787. [DOI] [PubMed] [Google Scholar]
10. Schäfer E., Schrenker C., Zupanc J., Bürklein S. Percentage of Gutta-percha Filled Areas in Canals Obturated with Cross-linked Gutta-percha Core-carrier Systems, Single-Cone and Lateral Compaction Technique. J. Endod. 2016; 42:294–298. doi: 10.1016/j.joen.2015.10.018. [DOI] [PubMed] [Google Scholar]
11. Krug R., Krastl G., Jahreis M. Technical quality of a matching-taper single-cone filling technique following rotary instrumentation compared with lateral compaction after manual preparation: A retrospective study. Clin. Oral Investig. 2017; 21:643–652. doi: 10.1007/s00784-016-1931-z. [DOI] [PubMed] [Google Scholar]
12. Brosh T., Metzger Z., Pilo R. Circumferential root strains generated during lateral compaction with stainless steel vs. nickel-titanium finger spreaders. Eur. J. Oral Sci. 2018;126:518–525. doi: 10. 1111/eos.12569. [DOI] [PubMed] [Google Scholar]
13. Koçak M.M., Darendeliler-Yaman S. Sealing ability of lateral compaction and tapered single cone gutta-percha techniques in root canals prepared with stainless steel and rotary nickel titanium instruments. J. Clin. Exp. Dent. 2012;4: e156–e159. doi: 10.4317/jced.50752. [DOI] [PMC free article] [PubMed] [Google Scholar]
14. Wu M.K., Bud M.G., Wesselink P.R. The quality of single cone and laterally compacted gutta-percha fillings in small and curved root canals as evidenced by bidirectional radiographs and fluid transport measurements. Oral Surg. Oral Med. Oral Pathol. Oral Radiol. Endod. 2009; 108:946–951. doi: 10.1016/j.tripleo.2009.07.046. [DOI] [PubMed] [Google Scholar]
15. Schäfer E., Nelius B., Bürklein S. A comparative evaluation of gutta-percha filled areas in curved root canals obturated with different techniques. Clin. Oral Investig. 2012; 16:225–230. doi: 10.1007/s00784-011-0509-z. [DOI] [PubMed] [Google Scholar]
16. McMichen F.R., Pearson G., Rahbaran S., Gulabivala K. A comparative study of selected physical properties of five root-canal sealers. Int.

Endod. J. 2003; 36:629–635. doi: 10.1046/j.1365-2591.2003.00701.x. [DOI] [PubMed] [Google Scholar]

17. Silva E.J.N.L., Cardoso M.L., Rodrigues J.P., De-Deus G., Fidalgo T.K.d.S. Solubility of bioceramic- and epoxy resin-based root canal sealers: A systematic review and meta-analysis. Aust. Endod. J. 2021;47:690–702. doi: 10.1111/aej.12487. [DOI] [PubMed] [Google Scholar]
18. Wu D., Tang Z., Zhang G., Liu W. The sealing ability of a new silicone-based root canal filling material (GuttaFlow): An in vitro study using the percentage of gutta-percha-filled area. Dent. Mater. J. 2011;30:569–575. doi: 10.4012/dmj.2010-194. [DOI] [PubMed] [Google Scholar]
19. Zielinski T.M., Baumgartner J.C., Marshall J.G. An evaluation of Guttaflow and gutta-percha in the filling of lateral grooves and depressions. J. Endod. 2008;34:295–298. doi: 10.1016/j.joen.2007.12.004. [DOI] [PubMed] [Google Scholar]
20. Donnelly A., Sword J., Nishitani Y., Yoshiyama M., Agee K., Tay F.R., Pashley D.H. Water sorption and solubility of methacrylate resin-based root canal sealers. J. Endod. 2007;33:990–994. doi: 10.1016/j.joen.2006.03.021. [DOI] [PubMed] [Google Scholar]
21. Patil P., Rathore V.P., Hotkar C., Savgave S.S., Raghavendra K., Ingale P. A comparison of apical sealing ability between GuttaFlow and AH plus: An in vitro study. J. Int. Soc. Prev. Community Dent. 2016;6:377–382. doi: 10.4103/2231-0762.186794. [DOI] [PMC free article] [PubMed] [Google Scholar]
22. Savariz A., González-Rodríguez M.P., Ferrer-Luque C.M. Long-term sealing ability of GuttaFlow versus Ah Plus using different obturation techniques. Med. Oral Patol. Oral Cir. Bucal. 2010;15:e936–e941. doi: 10.4317/medoral.15.e936. [DOI] [PubMed] [Google Scholar]
23. Teixeira F.B., Teixeira E.C., Thompson J., Leinfelder K.F., Trope M. Dentinal bonding reaches the root canal system. J. Esthet. Restor. Dent. 2004;16:348–354. doi: 10.1111/j.1708-8240. 2004.tb00066.x. discussion 354. [DOI] [PubMed] [Google Scholar]
24. Shipper G., Ørstavik D., Teixeira F.B., Trope M. An evaluation of microbial leakage in roots filled with a thermoplastic synthetic polymer-based root canal filling material (Resilon) J. Endod. 2004;30:342–347. doi: 10.1097/00004770-200405000-00009. [DOI] [PubMed] [Google Scholar]
25. Tay F.R., Pashley D.H. Monoblocks in root canals: A hypothetical or a tangible goal. J. Endod. 2007;33:391–398. doi: 10.1016/j.joen.2006.10.009. [DOI] [PMC free article] [PubMed] [Google Scholar]

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