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ORIGINAL ARTICLE

A CROSS-SECTIONAL STUDY ON MODERN TECHNOLOGIES IN DENTAL PRACTITIONERS OF ENDODONTICS IN ROMANIA BASED ON A QUESTIONNAIRE

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Abstract: (1) *Background*: The constant technological progress, occurring sometimes at a rapid pace, can be challenging for some dentists, demanding significant additional effort to acquire knowledge and adapt to new techniques. New methods and materials should be implemented throughout the medical field, regardless of the specialty, from establishing the diagnosis using three-dimensional imaging to the actual endodontic treatment. (2) *Methods*: This cross-sectional study was designed to assess Romanian dentists' use of modern endodontic techniques and materials through an online questionnaire targeting dentists who perform endodontic treatments as part of their clinical practice. The survey was conducted over seven months, from November 2022 to May 2023. (3) *Results*: 207 fully validated responses were obtained, resulting in a response rate of 69%. (4) *Conclusions*: Upon analysis of the questionnaire responses, a substantial proportion of medical professionals demonstrate openness to the utilization of contemporary technological advancements within the field of endodontics.

Keywords: endodontics, questionnaire, modern technologies

1. Introduction

The development of technologies, methods, and materials is prevalent nowadays, regardless of the field of practice. In the medical field, practitioners are in a continuous process of assimilating new concepts. Most technological advancements aim to facilitate the establishment of diagnoses, data interpretation, and the treatment process. However, choosing specific equipment or technology requires thorough information gathering beforehand and passing it through one's decision-making filter before being applied to in vivo treatments on patients [1].

The general dentist specialized in a certain branch of dentistry should always gain an in-depth understanding of a particular aspect of oral care, and continuous learning is their obligation through participation in specialized conferences and the study of international literature, which is constantly enriched with new insights [2].

From establishing the diagnosis using three-dimensional imaging to the actual endodontic treatment, new methods and materials should be implemented throughout the entire medical field, regardless of the specialty. CBCT is gradually replacing conventional retro-alveolar radiography; the endodontic access cavity is made using special burs or, even more recently, using a laser; the mechanical preparation of the root canals benefits from a multitude of file systems to choose from, which is beneficial in decreasing the working time and increasing the efficiency of the treatment; also, endodontic irrigation uses certain chemicals whose effect can be enhanced by different methods; canal obturation benefits from an explosion of materials and techniques; the definitive coronal restoration is, more recently, fully realized by using CAD/CAM systems and 3D printers [2,3].

This constant technological progress, occurring sometimes at a rapid pace, can be challenging for some dentists, demanding additional effort to acquire knowledge and adapt to new techniques. Moreover, using the dental microscope, scanning systems, and 3D printers may occasionally require physics or computer science knowledge that an early-generation medical practitioner might not possess [3-5].

Therefore, the advancements made in the technical and technological area require well-informed doctors who have an open mindset while also having a solid foundation of knowledge to discern between what is truly useful and beneficial and what is merely a marketing strategy [1,2].

The purpose of this study was to analyze the extent to which the current dental equipment is used, especially the one used in the field of endodontics, among dentists in Romania.

The objectives were set:

- Establishing the most frequently used imaging method for the diagnosis of endodontic pathologies.
- Determination of the percentage in which magnification is used in performing root canal treatments.
- Determination of the most frequent type of instrumentation used in endodontics.
- Determination of the most appreciated methods of potentiating the effect of the irrigants.

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- Determination of the most often used obturation techniques.
- Determination of the percentage of doctors who use bioceramic materials in their daily practice and their specialty.
- Determination of the indications for the use of calcium hydroxide in endodontics.
- Determination of the most approved methods of definitive restoration of endodontically treated teeth.

2. Materials and method

Study design

This cross-sectional study was designed to assess the use of modern endodontic techniques and materials by Romanian dentists through an online questionnaire targeting dentists who perform endodontic treatments as part of their clinical practice. The survey was conducted over a seven-month period from November 2022 to May 2023.

The target population consisted of Romanian dentists across various specializations, including general dentistry, endodontics, and other relevant fields, provided they perform endodontic treatments in their practice. The sample size was calculated using the IDSurvey Sample Size Calculator, with a 90% confidence level and a 5% margin of error.

Based on an estimated population of dentists practicing in Romania who perform endodontic treatments, the required sample size was determined to be 194. This ensured adequate statistical power to generalize the findings to the broader population of Romanian dentists.

Participants were recruited through professional dental networks, online forums, and social media platforms dedicated to dentistry. In total, 300 dental practitioners were invited to participate in this survey, and 210 answers were obtained.

The inclusion criteria were:

- Dentists practicing in Romania.
- Currently performing endodontic treatments.

Exclusion Criteria were as follows:

- Incomplete responses to all questions
- The responses were collected beyond the specified time frame.

As a result of our exclusion criteria, only 207 fully validated responses were included.

Data Collection

Data were collected via a structured, self-administered online questionnaire hosted on Google Forms (Google LLC, Mountain View, CA, USA). The questionnaire was developed by two members of the Endodontic Department in the Faculty of Dental Medicine, Craiova, Romania.

The questionnaire consisted of 15 closed-ended questions designed to assess the following:

- Demographics and Professional Information: The first two questions collected data on dental specialization and years of experience (seniority) in the dental field.
- Endodontic Practices: The remaining 13 questions focused on the participants' use of modern instruments, techniques, and materials in endodontic treatments, including the adoption of rotary and Ni-Ti instruments, magnification tools (e.g., microscopes), and advanced disinfection methods.

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Data Management and Statistical Analysis

Data were securely stored on Google Forms and were accessible only to the research team. After the data collection period concluded, the dataset was exported for statistical analysis.

Descriptive statistics were used to summarize participant demographics and endodontic practices, with results presented as frequencies and percentages. Chi-square tests and t-tests were used to compare responses based on specialization, years of experience, and other demographic factors, where applicable. Statistical significance was set at $p < 0.05$. All analyses were performed using IBM SPSS Statistics for Windows software, Version 29.0 (Armonk, NY, USA: IBM Corp.).

3. Results

In this cross-sectional study conducted among dentists practicing endodontics in Romania, a total of 207 fully validated responses were obtained, resulting in a response rate of 69%.

Regarding the specialization of the doctors participating in this study, the first place was occupied by the General Dentistry specialization, with a percentage of 50.24%, followed by Endodontics (25.12%), Prosthetics (8.70%), Oral-Maxillo-facial Surgery (6.76%), Pedodontics (5.80%) and Orthodontics (3.38%), as shown in Table 1.

Table 1. Respondent distribution based on postgraduate training.

Specialty	Number of Responses	Percentage (%)
General Dentistry	104	50.24
Endodontics	52	25.12
Prosthetics	18	8.70
Oral Maxillofacial Surgery	14	6.76
Pedodontics	12	5.80
Orthodontics	7	3.38
Total	207	100.00

The work experience was almost equally distributed: more than 10 years (29.9%); less than 2 years (25.5%); 6-10 years (22.9%), and 2-5 years (21.7%).

When choosing the radiological methods used in establishing the diagnosis of endodontic diseases, the participants could select one or more answers. Thus, the results were as observed in Table 2: 38.20% responses for retro-alveolar radiography, 34.21% for orthopantomography (OPG), and 27.57% for CBCT. When the statistical analysis was performed, we found that there is a statistically significant difference in the use of CBCT in establishing the diagnosis of endodontic diseases ($p<0.001$) between Endodontics specialists and doctors from other or no specialty.

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Table 2. Radiological Methods.

Radiological Methods	Respondents	Percentage (%)
Retro-alveolar radiography	115	38.20
Orthopantomography	103	34.21
CBCT	83	27.57

Regarding magnification, 37.61% of doctors do not use any kind of magnification method, while 34.86% use the microscope and 27.52% use loupes. It should be mentioned that this question had multiple answer options, so there are some respondents who use both methods of magnification (Table 3).

Table 3. Magnification Methods.

Magnification Methods	Respondents	Percentage (%)
Yes-Microscope	76	34.81
Yes-Loupes	60	27.52
No	82	37.61

Further statistical analysis of the data revealed that a significantly higher proportion of practitioners with Endodontics specialty used the microscope for magnification, compared with the other specialties, the difference being statistically significant ($p<0.001$).

When making the access cavity, the majority of doctors answered that they use special burs: 64.68%. Ultrasonic instruments are used by 27.77% of dentists, while the laser is used by only 7.53% of doctors participating in the questionnaire, as seen in Table 4.

Table 4. Access Cavity.

Access Cavity	Respondents	Percentage (%)
Special Burs	148	64.68
Ultrasound Tips	55	27.77
Laser	4	7.53

Regarding the creation of the access cavity, the doctors answered as follows: 50.3% of the doctors perform the conventional access cavity, 48.4% perform the conservative access cavity, and 1.3% perform the ninja access cavity (Figure 1). None of the doctors participating in the questionnaire made the access cavity directed to the openings of the root canals (truss access). When we compared the groups, we found out that there is a significant statistical correlation between doctors using magnification in their endodontic treatments and those performing the conservative and ninja access cavities ($p<0.001$).

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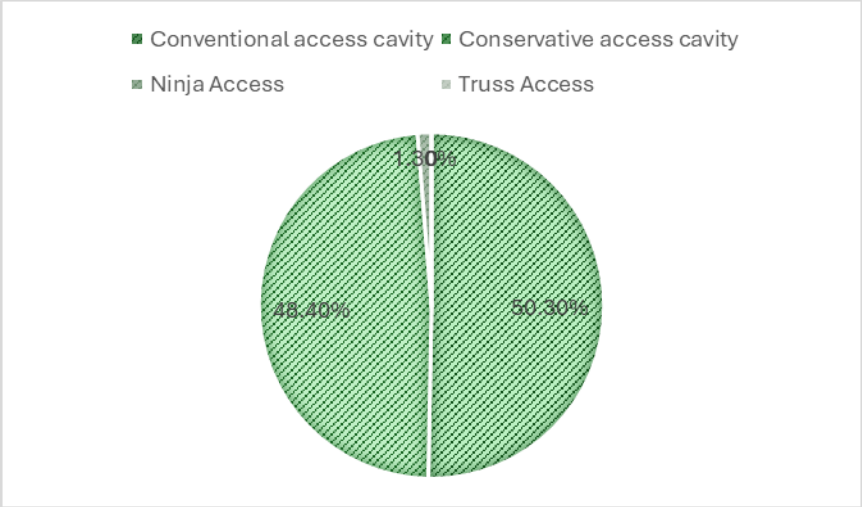

Figure 1. The preferred access cavity design.

The preferred instruments of the doctors participating in the questionnaire are Ni-Ti rotary instruments (40%), followed by manual instruments (35%) and memory-controlled rotary instruments (25%), as observed in Figure 2.

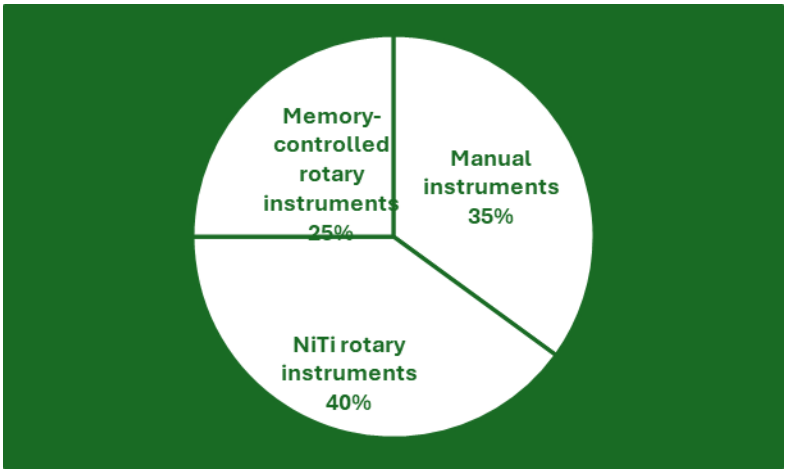

Figure 2. The preferred instruments.

In answering the following question, the participants expressed that they preferred the reciprocating movement (65.5%) despite continuous rotation (34.5%) (Figure 3). There was no statistically significant association between the specialty and the preference for a certain movement of the rotary endodontic instrument in root canal preparation ($p>0.001$).

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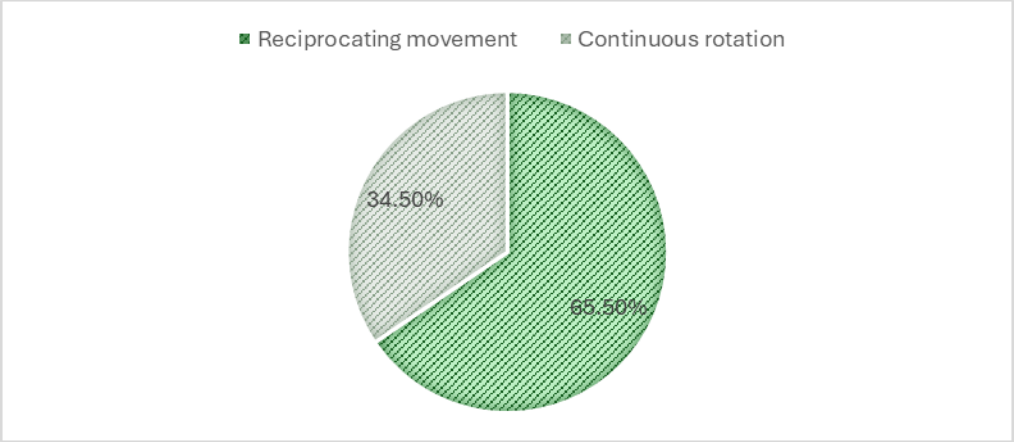

Figure 3. The preferred movement of the instruments.

Following the questionnaire, we found out that most of the doctors who completed it used additional means to enhance the effect of the irrigants, ultrasound being the favorite method (48.5%). At the opposite pole, 28.9% of the participants do not use additional means (Figure 4).

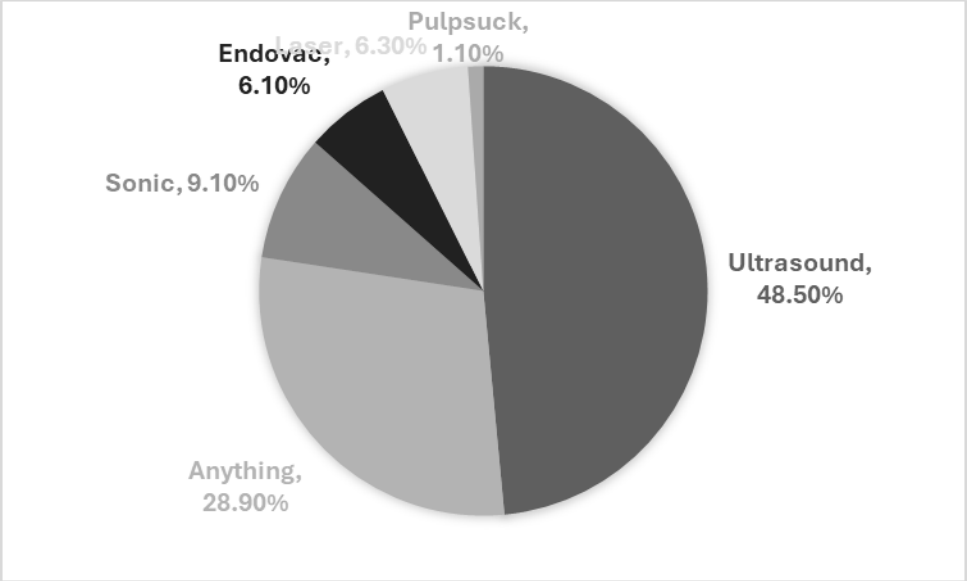

Figure 4. Additional means for irrigation.

In relation to the obturation technique, the doctors had six answer options, being able to choose one or more options. The preferred obturation technique was the single cone technique (29.58%), followed by warm vertical condensation (20.54%). The gutta-percha on rigid support had the lowest percentage (4.93%), as observed in Table 5.

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Table 5. Obturation Technique.

Method of obturation	Number of Responses	Percentage (%)
Single Cone	108	29.58
Warm vertical condensation	75	20.54
Injection	64	17.53
Cold lateral condensation	62	16.98
Continuous wave	38	10.41
Rigid obturation	18	4.93
Total	365	100.00

Also, regarding root canal obturation, 55.2% of the respondents stated that they use bioceramic materials in its realization, while 44.8% deny their use. The statistical analysis showed a statistically significant difference between the Endodontics specialists and the other groups of respondents ($p<0.001$).

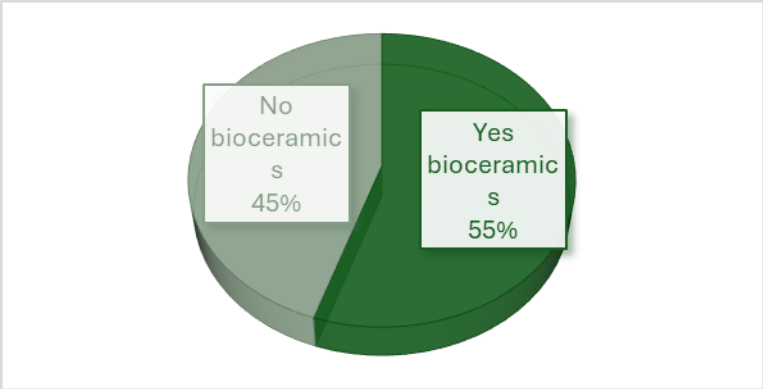

Figure 5. Use of bioceramics.

The following question aimed to identify the situations in which calcium hydroxide is used as a dressing between appointments. The question was multiple choice, and the doctors responded, as seen in Figure 6.

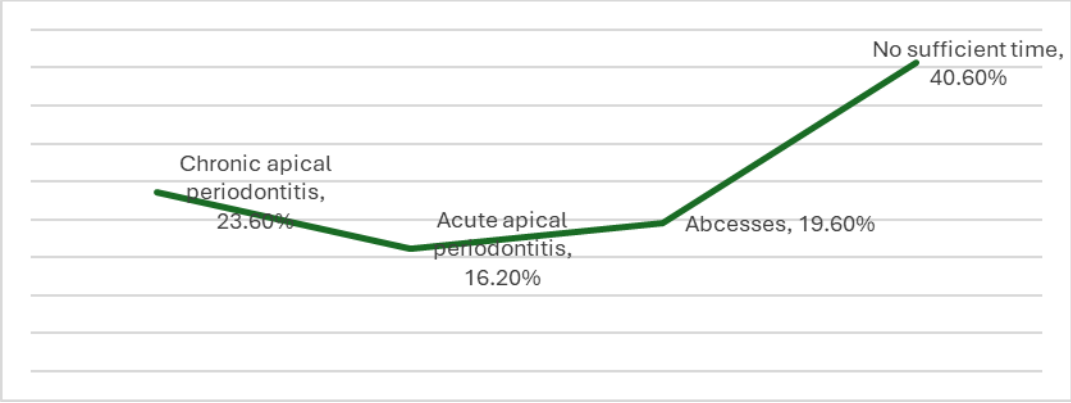

Figure 6. Use of Calcium Hydroxide.

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Regarding the restoration of endodontically treated teeth, 63.40% of doctors prefer full-coverage crowns, while 36.6% perform Inlay or Overlay. Doctors could choose one, two, or all three answer options (Figure 7).

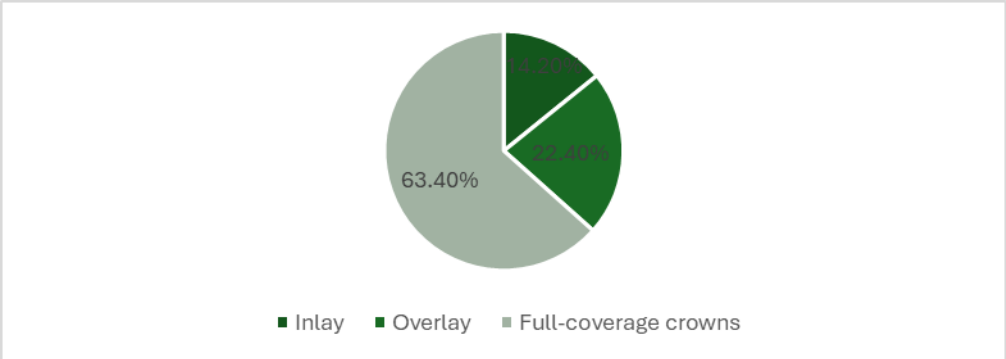

Figure 7. Final restoration of endodontic treated teeth.

4. Discussion

This study had as its starting point a questionnaire that included a total of 15 questions; the first two aimed at identifying specialization and work experience in dentistry, while the following 13 questions were designed to highlight the extent to which dentists use modern means and materials in the field of endodontics.

The work experience of the doctors varied. Most of the participants (29.9%) had over 10 years of experience. 25.5% of participants had less than 2 years, 22.9% had between 6 and 10 years, and only 21.7% had 2 and 5 years of experience.

Radiography is an essential method in endodontics for diagnosis, treatment planning, and execution, as well as for evaluating treatment success. In endodontics, image quality is extremely important for a correct interpretation of the endodontic system, visualizing possible canal curvatures, immediate postoperative assessment, and ongoing evaluation of treatment success [6]. OPG (Orthopantomography) is used for an overall assessment of the patient's dental status, providing a general view of the image and an easy visualization of the mandibular canal and the temporomandibular joint. Limitations of OPG include the anterior areas, nasal cavity floor, incisive foramen, and implant bony margins [7].

In our study, the majority of participants answered that they prefer radiography as an imaging method (38.20 % for retro-alveolar radiography and 34.21% for OPG), with CBCT being preferred by 27.57%. A similar study conducted by Mathew et al., in which the questionnaire was sent to doctors in Riyadh, Saudi Arabia, showed that the imaging method of choice was still radiography: 59.3% for conventional film radiography, 35.6% for digital radiography, and only 4% for CBCT [8].

In the same study, the majority of doctors (73.3%) responded that they have never used magnification tools such as loupes or microscopes, 16.3% use them occasionally, and only 3.7% use them every time [8]. The magnification-related results of this study are similar to the results of our study, with the

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majority (37.61%) not using magnification tools, while 27.52% responded that they use loupes, and 34.86% use microscopes. These results are promising for Romania, where access to technology is becoming increasingly easier.

An ideal imaging technique must be accurate, simple to perform, non-destructive, and feasible in an in vivo scenario. It has been concluded that CBCT is the most accurate method for identifying the endodontic system [9]. CBCT has a lower cost and lower radiation exposure, with the radiation dose a patient is exposed to being three times greater compared to traditional OPG. Despite the increased radiation dose, studies have shown that CBCT identifies at least 20% more periapical lesions than periapical radiographs [7,9,10].

Dental microscopes provide greater magnification capacity than loupes. An in vitro study conducted by Park et al. in 2014 showed that the presence of the MB2 canal was identified in 15.8% using loupes and in 70.5% using a microscope [11]. Another study by Nath and Shetty in 2017, with the same purpose, had the following results: naked eye - 68%, loupes - 76%, microscope - 100% [12].

In order to analyze the effectiveness of loupes, Wong et al. [13] conducted a study with the purpose of comparing the time required for endodontic treatment with and without the use of loupes. The study results indicated that there is a time difference between endodontic treatments performed with and without loupes. The use of loupes helped reduce the time required for non-surgical endodontic treatments, and dentists' reluctance to use loupes due to the argument that treatment time would be increased was not supported. Dentists who performed treatments using loupes concluded that treatment efficiency and accuracy were enhanced.

Regarding the instruments used for access cavity preparation, the majority (64.68%) reported using special burs, while 27.77% used ultrasonic instruments and only 7.53% used lasers. An important requirement for burs used in access cavity preparation is that they create a clean, smooth, and minimally vibrating cut. In cases of acute apical periodontitis, burs should be chosen to minimize vibration [14]. Erbium-based lasers are currently used for hard dental tissue removal, including for creating endodontic access cavities [15,16].

Because it's known that endodontically treated teeth are more susceptible to fracture [17], the study by Aydin et al. aimed to compare the fracture resistance of endodontically treated teeth when access cavities were prepared using conventional burs and Erbium lasers. The conclusion was that no significant differences were found between the group of teeth treated with burs and the group treated with lasers. Thus, in correlation with previous studies, it was suggested that fracture resistance is correlated with significant loss of hard tissue or micro-cracks produced during access cavity preparation [18].

The preferred access cavity among Romanian dentists is the conventional access cavity (50.3%), closely followed by the conservative access cavity (48.4%). A small percentage (1.3%) use the Ninja access cavity. An ideal access cavity should allow for the complete removal of pulp tissue,

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debris, and necrotic materials. However, it's important to note that the smaller the cavity, the higher the risk of bacterial contamination due to incomplete tissue removal and the higher the risk of missing some root canals [19]. Several authors maintain that the conservative access cavity does not provide endodontically treated teeth with more excellent fracture resistance than the traditional access cavity [20,21]. In a study by Tsotsis et al. [21], 56.6% of participants preferred to perform CEC (Conservative Endodontic Cavity), 42.7% preferred TEC (Traditional Endodontic Cavity), and only 0.7% preferred ultraconservative access cavities [21].

In our study, the majority of dentists (40%) reported using NiTi rotary instruments, while manual instrumentation was used by 35% of the dentists. About 25% used controlled memory instruments. Similarly, in Turkey, out of 204 dentists, 76% (n=155) reported using NiTi rotary instruments [22]. In Chennai, India, in 2018, 31% of dentists used only rotary instruments, 13% used only manual instruments, and 56% used both types [23]. In 2021, 42% used only manual instruments, 16% used only rotary instruments, and 42% used both types [24]. In Brazil, in 2018, 82.20% of endodontists and 74.30% of general dentists used continuous rotary motion with manual instruments, and 76.80% and 73.80%, respectively, used reciprocating systems in combination with manual instruments. Their reasons for choosing single-file reciprocating systems were faster preparation and obturation and improved endodontic technique [25].

The two movement options available to Romanian dentists for rotary instruments were reciprocal motion (65.5%) and continuous rotation (34.5%). It's important to note that this question allowed for multiple answers, meaning dentists could choose both options. During root canal preparation, when the instrument comes into contact with the canal walls, there are moment forces on the dentin that can result in dentin defects and later, vertical root fractures. It has been reported that reciprocal motion reduces torsional stress by periodically reversing the direction of rotation of the instrument. This can help reduce the magnitude of forces generated on dentin walls and prevent cracks and root fractures [26].

In 2024, C. Diaconu et al. found that continuous rotation movement was preferred by 47% of the respondents, while reciprocating movement was preferred by 20.4% of the study participants. These results are quite opposite to ours, even though the respondents were from Romania in both studies [27].

Based on the questionnaire, it was concluded that the majority of dentists in Romania use methods to enhance irrigation solutions, including ultrasonic devices, ultrasonic machines, Pulpsuck, Endovac, and lasers. 28.9% reported not using any irrigation enhancement methods. Conventional irrigation penetrates dentinal tubules to a depth of up to 130 microns, while bacterial colonies have been found even at a depth of 1.15 mm within the dentinal tubules beyond the main root canal [28]. Activation of the irrigant using laser-activated irrigation (LAI) technology allows Er,Cr:YSGG and Er:YAG lasers. The wavelengths of these

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lasers range from 2,780 to 2,940 nm, making them absorbed by water and sodium hypochlorite [29]. Studies have reported that irradiating the root canal simultaneously or after the irrigation protocol (distilled water, EDTA, chlorhexidine, sodium hypochlorite) results in a similar or even improved morphological dentin surface pattern compared to after simple irrigation [28]. When laser irradiation occurs after EDTA irrigation, cleaner surfaces are achieved, with less debris, open dentinal tubules, and minimal thermal alteration compared to irradiation in a dry environment [30].

Root canal obturation is an important step in endodontic treatment, aiming to achieve a three-dimensional tight seal of the root canals. According to our study, the single-cone obturation technique was the winner, chosen by 29.58%. This technique is easy to perform, takes less time, and has a low cost [31]. Despite its advantages, the single-cone technique requires a significant amount of sealer, and therefore, the fluidity and physicochemical properties of the sealer play an essential role in the success of endodontic treatment [32].

In Nepal, according to Manandhar et al. 2020, the following results were obtained: single-cone technique 13.41%, lateral cold condensation 95.12%, vertical warm condensation 1.21%, and thermoplastic techniques 2.43% [33]. According to Geetha et al., lateral condensation in combination with sealer is the most accepted obturation technique among practitioners [34].

In 2020, Gheorghe A. et al. conducted a study in which they analyzed teeth with three types of root canal fillings - single cone, cold lateral condensation, and warm vertical condensation. Seventeen teeth were obturated using the single cone technique, and after extractions, they were examined using a stereo-microscope. The following observations were made based on the analysis: in all teeth, the cone was shorter than the working length and did not match the prepared shape of the root canal; macroscopic voids and infiltrations were identified in the sealer, which had uneven coloration; morphological variations such as canals dividing into the apical third or oval canals could not be obturated [35].

Bioceramic materials are biocompatible with human tissues and exhibit excellent sealing capacity. They also possess antibacterial and antifungal properties [36]. In our conducted study, the majority of healthcare professionals (55.2%) reported using bio-ceramic materials in performing root canal obturations. However, the percentage of professionals not using such materials (44.8%) is quite close to those who do. The most popular bioceramic materials used by medical practitioners in Romania include BioMTA (Cerkamed), Biodentine (Septodont), ProRoot MTA (Dentsply), and BioRoot RCS (Septodont). MTA (Dentsply-Tulsa Dental, Johnson City, TN, USA) is an osteoconductive, osteoinductive, and biocompatible material that reaches a pH of 12.5 three hours after preparation [36].

As a result, due to its strong alkaline pH, MTA has an effect on Enterococcus faecalis, Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa, Porphyromonas gingivalis, and Candida albicans [37,38]. Biodentine (Septodont, Saint Maur des Fosses, France) is a non-toxic bioceramic material that induces angiogenesis, cellular

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differentiation, and mineralization. It presents several advantages over MTA, including easier handling, better mechanical properties, the ability to perform restorations in a single step, faster setting reaction, and a lower risk of bacterial contamination [36, 39].

Biocompatibility, excellent sealing ability, tissue conduction and induction, and a high success rate have made bioactive types of cement the materials of choice for performing root end fillings (apical obturations). Despite several cements being evaluated as materials for apical third obturation, MTA remains the gold standard and the reference point when testing new materials [40]. Several studies have assessed the influence of the material used in this type of obturation on treatment outcomes [41,42].

Bioactive endodontic types of cement can be used as root-filling materials on their own or in combination with gutta-percha. Several studies have shown successful treatments when using materials such as MTA Angelus, ProRoot MTA, Biodentine, BioAggregate, and CEM for obturating both temporary and permanent teeth with necrotic pulpal tissue, with complete or incomplete apex formation [43-50].

Numerous studies have highlighted the use of bioactive types of cement in treating cervical resorptions and internal and external root resorptions [51-54]. Due to its low compressive strength, MTA is not recommended for creating temporary or permanent coronal restorations. However, the manufacturer of the material Biodentine recommends its use for temporary coronal restorations. After 6 months, material abrasion was the reason patients returned to the clinic for definitive restoration [55]. The contact of Biodentine with dentin led to the forming of a thicker reparative dentin layer than Dycal in class V cavities [40].

In our study, most of the clinicians responded that they use calcium hydroxide as interim medication in cases where they cannot complete the root canal treatment in a single session (40.60%). In 2012, clinicians in Turkey used calcium hydroxide at a rate of 53.2% [22], and by 2015, the proportion had increased to 82.4% [22]. In Nepal, the percentage was 98.78% [33]. In Saudi Arabia, in 2014, only 4% used calcium hydroxide as intra-canal medication [56], and by 2015, the percentage had reached 36.3%, with 45.2% stating that they did not use any medicines between sessions [3]. The results obtained by Mathew et al. are lower compared to those obtained in Flanders, Belgium (69%), and in northern Jordan (63%) [3].

The protocol for multiple visits requires the placement of a medicament in the form of a paste into the root canal, with the purpose of disinfection [57]. Placing an antimicrobial agent in the root canal (for a week or more) allows the active ingredients to diffuse from the paste through the root canal into the root dentin, reaching microorganisms deep within dentinal tubules. The need for an intra-canal medicament is better in cases where present bacteria or fungi are resistant to conventional endodontic treatment. Such bacteria serve as sources of root canal reinfection. The active ingredients released from endodontic medicaments can penetrate dentinal tubules and neutralize bacteria at that level [58].

The most common intra-radicular medicament is calcium hydroxide. It can also

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be used for apexification and direct capping procedures [59,60]. The released calcium ions play an important role in cellular stimulation, migration, and proliferation, and in the mineralization and repair of hard tissues [58].

Although this survey includes a limited number of respondents, the data obtained offer valuable insights and can serve to outline and compare the current standards of endodontic practice in Romania. Further research will undoubtedly make a significant contribution to the scientific literature. In this study, there is a lack of information regarding the objective evaluation of the respondents' practices. Additionally, it relies solely on the practitioners' self-assessments of the quality of their work, with no methods in place to objectively verify the correct application of medical techniques or proper use of materials and instruments. Conducting a cross-sectional radiological study with follow-up evaluations at specific intervals could offer more detailed insights into the quality of endodontic therapy performed by Romanian practitioners and yield more reliable data.

5. Conclusions

The aim of the questionnaire was to assess the protocols followed by dental practitioners in Romania and the degree of adoption of modern endodontic technology in root canal treatments.

Upon analysis of the questionnaire responses, a substantial proportion of medical professionals demonstrate openness to utilizing contemporary technological advancements in endodontics.

Nonetheless, it is noteworthy that certain phases of the endodontic treatment process continue to align with conventional methodologies among dentists in Romania, methods that have demonstrated their efficacy over time.

References

1. Versiani M. Technology in Endodontics: A Double-Edged Sword? AAE. 2021.
2. Iandoloa A, Iandolob G, Malvanoc M, Pantaleoa G, Simeone M. Modern technologies in Endodontics. Giornale Italiano di Endodonzia. 2016;30: 2–9.
3. Ferreira I da C, Ferreira G da C, Tavares W.L.F., Côrtes MI de S, Braga T, Amaral RR. Use of technology in endodontics by undergraduate dental students in a south-eastern state of Brazil. European Journal of Dental Education. 2021;25(2): 225–231.
4. Kimura Y, Wilder-Smith P, Matsumoto K. Lasers in endodontics: a review. Int Endod J. 2000;33(3):173–85.
5. Kapetanaki I, Dimopoulos F, Gogos C. Traditional and minimally invasive access cavities in endodontics: a literature review. Restor Dent Endod. 2021;46(3):e46.
6. Lo Giudice R, Nicita F, Puleio F, Alibrandi A, Cervino G, Lizio AS, et al. Accuracy of periapical radiography and CBCT in endodontic evaluation. Int J Dent. 2018;2018:2514243. doi: 10.1155/2018/2514243.
7. Bonfanti E, Maddalone M, Pellegatta A, Citterio CL, Baldoni M. Digital orthopantomography vs cone beam computed tomography-part 2: a CBCT analysis of factors influencing the prevalence of periapical lesions. J Contemp Dent Pract. 2019;20(6):664–9. PMID: 31358706.
8. Mathew S, Nafea M. Evaluation of the current endodontic trends among general

dental practitioners and specialists in Riyadh, KSA. Int J Innov Educ Res. 2015;3:8–19. doi: 10.31686/ijier.vol3.iss9.428.
9. Patel S, Brown J, Semper M, Abella F, Mannocci F. European Society of Endodontology position statement: Use of cone beam computed tomography in endodontics. Int Endod J. 2019. doi:10.1111/iej.13187.
10. Maddalone M, Bonfanti E, Pellegatta A, Citterio CL, Baldoni M. Digital orthopantomography vs cone beam computed tomography-part 1: Detection of periapical lesions. J Contemp Dent Pract. 2019;20(5):593–7. PMID: 31316024.
11. Park E, Chehroudi B, Coil JM. Identification of possible factors impacting dental students' ability to locate MB2 canals in maxillary molars. J Dent Educ. 2014;78:789–95.
12. Nath KS, Shetty K. Comparative evaluation of second mesiobuccal canal detection in maxillary first molars using magnification and illumination. Saudi Endod J. 2017;7:166.
13. Wong AW, Zhu X, Zhang S, Li SK, Zhang C, Chu CH. Treatment time for non-surgical endodontic therapy with or without a magnifying loupe. BMC Oral Health. 2015;15:40. doi:10.1186/s12903-015-0025-7.
14. Adams N, Tomson PL. Access cavity preparation. Br Dent J. 2014;216(6):333–9. doi:10.1038/sj.bdj.2014.206.
15. Bahrololoomi Z, Heydari E. Assessment of tooth preparation via Er:YAG laser and bur on microleakage of dentin adhesives. J Dent (Tehran). 2014;11:172–8.
16. Stănuși A, Popa D, Ionescu M, Cumpătă C, Petrescu G, Țuculină MJ, Dăguci C, Diaconu O, Gheorghiță L. Analysis of temperatures generated during conventional laser irradiation of root canals—a finite element study. Diagnostics (Basel). 2023;13(10).
17. Pilo R, Metzger Z, Brosh T. Effect of root morphology on the susceptibility of endodontically treated teeth to vertical root fracture: An ex-vivo model. J Mech Behav Biomed Mater. 2017;69:267–74.
18. Aydın U, Aksoy F, Tosun S. Fracture resistance of root-filled teeth after cavity preparation with conventional burs, Er and Er,Cr lasers. Eur Oral Res. 2018;52(2):59–63.
19. Moore B, Verdelis K, Kishen A. Impacts of contracted endodontic cavities on instrumentation efficacy and biomechanical responses in maxillary molars. J Endod. 2016;42:1779–83.
20. Silva EJNL, Rover G, Belladonna FG, De-Deus G, da Silveira Teixeira C, da Silva Fidalgo TK. Impact of contracted endodontic cavities on fracture resistance of endodontically treated teeth: a systematic review of in vitro studies. Clin Oral Investig. 2018;22:109–18.
21. Tsotsis P, Dunlap C, Scott R, Arias A, Peters OA. A survey of current trends in root canal treatment: access cavity design and cleaning and shaping practices. Aust Endod J. 2021;47(1):27–33. doi:10.1111/aej.12449.
22. Küçükkaya Eren S, Gorduysus M, Gorduysus O, Anil D. A questionnaire survey on current endodontic practice of dental practitioners in Turkey. Clin Dent Res. 2015;101–9.
23. Patturaja K, Leelavathi L, Jayalakshmi S. Choice of rotary instrument usage among endodontists—a questionnaire study. Biomed Pharmacol J. 2018;11(2).
24. Saravanan K, Hameed S. Knowledge and practice of endodontic treatment carried out by general practitioners in Chennai: a questionnaire survey. Int J Soc Rehabil. 2021;6:36–9.

25. Georjutti R, Miura F, Faria R, De Martin A, Bueno C. Identification of the profile and perceptions of Brazilian dentists regarding the use of rotary and/or reciprocating instruments in endodontic treatment. Revistas. 2017;74:191.
26. Jamleh A, Komabayashi T, Ebihara A, et al. Root surface strain during canal shaping and its influence on apical microcrack development: a preliminary investigation. Int Endod J. 2015;48:1103–11.
27. Diaconu C, Gheorghita L, Diaconu A, Tuculina MJ, Gliga A, Gaeta C, et al. Current endodontic practices among Romanian dental practitioners: a cross-sectional study. Dent J. 2024;12:283.
28. Adrian ŞS, Lelia MG, Andreea S, Oana AD, Anca G, Ruxandra VG, et al. Endodontic bacterial reduction using diode laser radiation—short literature review. Rom J Oral Rehabil. 2020;12(3):8–19.
29. Meire MA, Poelman D, De Moor RJ. Optical properties of root canal irrigants in the 300–3,000 nm wavelength region. Lasers Med Sci. 2014;29(5):1557–62.
30. Olivi G, De Moor R, Divito E. Lasers in Endodontics—Scientific Background and Clinical Applications. 2016.
31. Girelli CF, Lacerda MF, Lemos CA, Amaral MR, Lima CO, Silveira FF, Nunes E. The thermoplastic techniques or single-cone technique on the quality of root canal filling with tricalcium silicate-based sealer: an integrative review. J Clin Exp Dent. 2022;14(7):e566–e572. doi: 10.4317/jced.59387.
32. Santos-Junior AO, Tanomaru-Filho M, Pinto JC, Tavares KIMC, Torres FFE, Guerreiro-Tanomaru JM. Effect of obturation technique using a new bioceramic sealer on the presence of voids in flattened root canals. Braz Oral Res. 2021;35:e028.
33. Manandhar A, Kunwar D, Shrestha S. Assessment of practice of endodontic treatment protocols among general dental practitioners in Pokhara, Nepal. Med J Pokhara Acad Health Sci. 2020;3(2):298–304.
34. Geetha RV, Veeraraghavan VP. Evaluation of antibacterial activity of five root canal sealants against Enterococcus faecalis: an in vitro study. Int J Pharm Pharm Sci Rev Res. 2016;40:221–3.
35. Gheorghe AG, Mercut V, Popescu SM, Tuculina MJ, Diaconu OA, Gheorghita LM, Gingu O. Microscopic study of the endodontic obturation sealing ability. Rom J Oral Rehabil. 2020;12(1):8–19.
36. Raghavendra SS, Jadhav GR, Gathani KM, Kotadia P. Bioceramics in endodontics: a review. J Istanbul Univ Fac Dent. 2017;51(3 Suppl 1):S128–S137. doi: 10.17096/jiufd.63659.
37. Pelepenko LE, Saavedra F, Antunes TBM, Bombarda GF, Gomes BPFA, Zaia AA, et al. Physicochemical, antimicrobial, and biological properties of White-MTAFlow. Clin Oral Investig. 2021;25:663–72.
38. Huang Y, Li X, Mandal P, Wu Y, Liu L, Gui H, Liu J. The in vitro antimicrobial activities of four endodontic sealers. BMC Oral Health. 2019;19:118.
39. Singh H, Kaur M, Markan S, Kapoor P. Biodentine: a promising dentin substitute. J Interdiscip Med Dent Sci. 2014;2:140.
40. Torabinejad M, Parirokh M, Dummer PMH. Mineral trioxide aggregate and other bioactive endodontic cements: an updated overview - part II: other clinical applications and complications. Int Endod J. 2018;51(3):284–317. doi: 10.1111/iej.12843.
41. Tortorici S, Difalco P, Caradonna L, Tete S. Traditional endodontic surgery versus modern technique: a 5-year controlled clinical trial. J Craniofac Surg. 2014;25:804–7.

42. Shinbori N, Grama AM, Patel Y, Woodmansey K, He J. Clinical outcome of endodontic microsurgery that uses EndoSequence BC root repair material as the root-end filling material. J Endod. 2015;41:607–12.
43. Costa GM, Soares SM, Marques LS, Gloria JC, Soares JA. Strategy for apexification of wide-open apex associated with extensive periapical lesion in a weakened root. Gen Dent. 2013;61:e2–4.
44. Shekhar V, Arora R, Roy M. Role of cone beam computed tomography and white mineral trioxide aggregate in the successful management of a permanent anterior tooth with open apex. J Int Oral Health. 2014;6:68–72.
45. Teixido M, Abella F, Duran-Sindreu F, Moscoso S, Roig M. The use of cone-beam computed tomography in the preservation of pulp vitality in a maxillary canine with type 3 dens invaginatus and an associated periradicular lesion. J Endod. 2014;40:1501–4.
46. Ashkenazi M, Kaufman A, Einy S. The diagnostic and treatment challenges associated with traumatized intruded permanent incisors: a case report. Quintessence Int. 2015;46:309–15.
47. Olczak K, Pawlicka H. Mineral trioxide aggregate in treatment of permanent teeth with open apex and endo-perio lesions: a case report. Eur J Paediatr Dent. 2015;16:287–9.
48. Heydari A, Rahmani M, Heydari M. Removal of a broken instrument from a tooth with apical periodontitis using a novel approach. Iran Endod J. 2016;11:237–40.
49. Martens L, Rajasekharan S, Cauwels R. Endodontic treatment of trauma-induced necrotic immature teeth using a tricalcium silicate-based bioactive cement.A report of 3 cases with 24-month follow-up', European Journal of Paediatric Dentistry, 17, pp. 24–28.
50. Parirokh M, Farzaneh S, Hallajmofrad AR. Conservative management of unset mineral trioxide aggregate root-end filling: a case report. Iran Endod J. 2016;11:241–5.
51. Arora S, Gill GS, Saluja P, Setia V. Management of a rare case of communicating internal-external inflammatory resorption. J Clin Diagn Res. 2015;9:ZD39–40.
52. Bendyk-Szeffer M, Łagocka R, Trusewicz M, Lipski M, Buczkowska-Radlińska J. Perforating internal root resorption repaired with mineral trioxide aggregate caused complete resolution of odontogenic sinus mucositis: a case report. J Endod. 2015;41:274–8.
53. Karypidou A, Chatzinikolaou ID, Kouros P, Koulaouzidou E, Economides N. Management of bilateral invasive cervical resorption lesions in maxillary incisors using a novel calcium silicate-based cement: a case report. Quintessence Int. 2016;47:637–42.
54. Sharifi R, Parirokh M, Satvati SAR, Torabinejad M. Treatment of inflammatory root resorption using mineral trioxide aggregate: a case report. Dent Hypotheses. 2014;5:172–6.
55. Koubi G, Colon P, Franquin JC, et al. Clinical evaluation of the performance and safety of a new dentine substitute, Biodentine, in the restoration of posterior teeth: a prospective study. Clin Oral Investig. 2013;17:243–9.
56. Iqbal A, Akbar I, Qureshi B, Sghaireen MG, Al-Omiri MK. A survey of standard protocols for endodontic treatment in North of KSA. ISRN Dent. 2014;2014:865780.
57. Kiran S, Prakash S, Siddharth PR, Saha S, Geojan NE, Ramachandran M. Comparative evaluation of smear layer and debris on the canal walls prepared with a combination of

hand and rotary ProTaper technique using scanning electron microscope. J Contemp Dent Pract. 2016;17:574–81.
58. Athanassiadis B, Walsh LJ. Aspects of solvent chemistry for calcium hydroxide medicaments. Materials (Basel). 2017;10(10):e1219. doi: 10.3390/ma10101219.
59. Ha WN, Duckmanton P, Kahler B, Walsh LJ. A survey of various endodontic procedures related to mineral trioxide aggregate usage by members of the Australian Society of Endodontology. Aust Endod J. 2016;42:132–8.
60. Madarati AA, Zafar MS, Sammani AMN, Mandorah AO, Bani-Younes HA. Preference and usage of intracanal medications during endodontic treatment. Saudi Med J. 2017;38:755–63.

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Data availability at request.

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ORIGINAL ARTICLE

NON-SURGICAL ENDODONTIC RETREATMENT IN CASE OF FAILURE OF PRIMARY ENDODONTIC TREATMENT: CASE SERIES

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Abstract: (1) *Background*: Nonsurgical endodontic retreatment procedures have a high potential for success when case selection guidelines are followed, advanced technologies and techniques are employed, and the best materials are used. The aim of the study is to demonstrate that conservative orthograde endodontic retreatment represents a safe management solution for cases of primary endodontic treatment failure. (2) *Methods*: The study was undertaken between 2022 and 2024, involving a cohort comprising 30 patients of diverse gender and age demographics who sought treatment at the Endodontics Clinic from the University of Medicine and Pharmacy from Craiova and received an endodontic retreatment. The study included three groups: one with inadequate coronal and root canal obturation, another with clinical symptoms, and the third with radiological signs of apical periodontitis. (3) *Results*: Orthograde endodontic retreatment is a conservative method of keeping the tooth on the arch, but it needs technology to establish the diagnosis and to perform the treatment itself. (4) *Conclusions*: In cases of primary orthograde endodontic treatment failure, modern endodontic management emphasizes repeating a conservative approach, reserving surgical endodontic intervention only as a last resort.

Keywords: endodontic retreatment, nonsurgical, conservative

1. Introduction

Endodontic treatment aims to achieve a functional tooth while also enabling the complete repair of the supporting structures. It is essential to consider all treatment options—conservative orthograde retreatment, retrograde retreatment, or extraction—based on factors such as time, cost, prognosis, and the patient's decision [1]. According to the Glossary of Endodontic Terms, "retreatment" refers to the performance of endodontic treatment that involves removing filling material from the root canals, followed by their cleaning, shaping, and obturation [2].

The endodontic retreatment procedure is classified into two major categories: orthograde (non-surgical) or conventional retreatment, performed in cases where the primary orthograde treatment was inadequate or in the event of failure of previous endodontic therapies, and retrograde (surgical) retreatment, which involves treatment following the surgical exposure of the apical portion of the tooth [3]. Orthograde endodontic treatment has proven to be a predictable procedure with a high success rate; however, failures may still occur, with rates ranging from 14% to 16% [4-7].

Nonsurgical endodontic retreatment procedures have a high potential for success when case selection guidelines are followed, advanced technologies and techniques are employed, and the best materials are used [8,9]. Orthograde endodontic retreatment is indicated in cases of failed endodontic treatment; however, the efficient removal of root canal filling material from the canal system is essential to ensure a successful outcome for the procedure [10].

"Failure" has variable definitions, with some studies describing it as the recurrence of clinical symptoms accompanied by the presence of periapical radiolucency [11]. An endodontically treated tooth must be evaluated both clinically and radiographically, and the patient should be scheduled for periodic follow-ups to ensure that the treatment is considered successful and the tooth remains functional [12].

The European Society of Endodontology has proposed guidelines for assessing the outcomes of endodontic treatment, defining the terms "success" and "failure" in endodontics. Primary orthograde endodontic treatment should be evaluated at least one-year post-treatment. A favorable outcome is characterized by the absence of clinical symptoms (e.g., pain, swelling, fistula), a radiographic image free from pathological signs, and a functional tooth. Conversely, an unfavorable outcome should be assessed if any of the following findings are present: clinical signs and symptoms, a radiographically visible periapical lesion that developed after treatment, a pre-existing periapical lesion that has increased in size, a periapical lesion that has remained the same size, or one that has only slightly diminished during a four-year evaluation period, or radiographic evidence of root resorption. In cases where the lesion has either remained the same size or reduced in volume after one year, the outcome is deemed uncertain, necessitating additional follow-up for up to four years [13].

Patient-centered terminology has also been proposed for evaluating endodontic outcomes, categorizing cases as "functional," "healed," "unhealed," and "healing" [8].

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The aim of our study is to demonstrate that conservative orthograde endodontic retreatment represents a safe management solution for cases of primary endodontic treatment failure.

This paper aims to evaluate the various reasons that lead to the decision to perform orthograde retreatment, which must be individualized to ensure this therapeutic approach meet\ing the needs of both the patient and the clinician.

2. Materials and method

The study was undertaken from 2022 to 2024, involving a cohort comprising 30 patients of diverse gender and age demographics, ranging from 30 to 60 years. These individuals sought treatment at the Endodontics Clinic from the University of Medicine and Pharmacy from Craiova to manage various dental pathologies and to restore masticatory and facial functionality. All patients were subjected to clinical and radiological examination to ascertain the dentition underlying pathology and received an endodontic retreatment.

A comprehensive endodontic chart and treatment form was meticulously completed for each participant involved in the study. This document encompassed personal information, reasons for presentation, familial and personal medical history, diagnostic findings, and proposed treatment strategies. In the selection of cases, due consideration was given to the endodontic, restorative, and periodontal prognoses. All therapeutic interventions were conducted with explicit informed consent obtained from the patient.

Clinical cases involving endodontic retreatments were selected and grouped into three categories based on the reasons for retreatment:

- deficient coronal and root canal obturation,
- presence of symptoms,
- presence of radiolucent signs.

The protocols for conservative endodontic retreatments were conducted according to the following procedure:

- Anesthesia administration; rubber dam isolation; complete removal of the infiltrated obturations and altered dentin;
- The build-up was performed using light-cured composite (Filtek Z250 XT, 3M ESPE)
- The root canals were reopened using stainless steel hand files (ISO 0.02) and Ni-Ti rotary instruments S2, F1 (Pro Taper Dentsply-Maillefer), with orange oil as the solvent.
- In some cases, the missed canal was identified, and a glide path for the rotary files was created using stainless steel hand K-files sizes 10, 15, and 20).
- Working lengths were determined with the Root ZX apex locator (Morita) and verified with retro-alveolar x-rays.
- Mechanical debridement was performed by enlarging the root canals using the progressive telescoping technique (Crown-Down) with stainless steel hand files (ISO 0.02) and Ni-Ti rotary instruments ProTaper Gold (F2, F3 Gold, Dentsply-Maillefer) and Reciproc R40 (VDW, Germany), based on the apical constriction diameter for each canal.
- Endodontic irrigation was carried out using 5.25% NaOCl, with 2 ml irrigation

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after each file, maintained for 20 minutes, and refreshed every 5 minutes for each canal, followed by 10% citric acid and 9% saline, sonically activated with Eddy (Dentsply-Maillefer).

- The canals were dried using paper points matching the taper of the system used.
- Root canal obturation was performed using gutta-percha cones calibrated to the master file taper with the continuous wave vertical condensation technique, aided by the Fast Fill and Back-Fill devices (Eighteeth) and AH Plus Jet sealer.
- A crown-root reconstruction was performed by adapting a fiberglass post (Overfibres, Italy), cemented with LuxaCore Z-Dual (DMG, Germany).
- An immediate postoperative two-dimensional radiograph was taken to verify the accuracy of the retreatment.
- Notably, all procedures were executed under magnification employing the Leica M320 dental microscope, augmenting visual acuity and procedural safety.

3. Results

The study included 30 participants, comprising 18 females (60%) and 12 males (40%). Most participants resided in urban areas (21, 70%), while 9 (30%) lived in rural locations. The age distribution showed that 8 participants (26.7%) were aged 30–40 years, 7 (23.3%) were aged 41–50 years, and the largest group, 15 participants (50%), were aged 51–60 years.

Regarding the causes of failure, 13 teeth (43.3%) had infiltrated obturations, 7 teeth (23.3%) presented with symptomatic apical periodontitis, and 10 teeth (33.3%) exhibited periapical radiolucencies (Table 1).

Table 1. Demographic and Clinical Characteristics of Study Participants.

Characteristic	Category	n	%
Gender	Female	18	60
	Male	12	40
Place of Living	Urban	21	70
	Rural	9	30
Age Group (years)	30-40	8	26.7
	41-50	7	23.3
	51-60	15	50
Causes of Failure	Teeth with infiltrated obturation	13	43.3
	Teeth with symptomatic apical periodontitis	7	23.3
	Teeth with apical radiolucencies	10	33.3

This section exhibits 3 of the most representative cases.

Case no 1: A 37-year-old female patient presented at the clinic, reporting discomfort, food impaction, and fetid halitosis in the region of the upper left molars, where an improperly adapted dental bridge was observed. The patient mentioned that she rarely used this area for mastication due to occasional discomfort.

A thorough clinical examination was conducted using inspection, palpation, and axial percussion, revealing the following findings:

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- A dental bridge spanning 2.4–2.6 exhibited mobility and poor marginal adaptation at 2.4 and 2.6.
- At 2.6, a supporting tooth, the full-coverage crown was improperly fitted, with a marginal secondary carious lesion.
- Axial and transverse percussion tests were negative for tooth 2.6.
- Palpation of the vestibule at the apex of the 2.6 root was non-tender, with no fluctuation detected.
- Thermal vitality tests (cold and hot) were not performed, as the tooth had undergone previous endodontic treatment.

Radiological examination of 2.6 (Figure 1) revealed:

- An improperly adapted full-coverage crown with marginal secondary caries.
- A previously performed endodontic treatment with an incomplete and non-homogeneous canal obturation.

A three-dimensional radiographic examination further identified:

- The presence of a missed canal (MB2).
- A radiolucent lesion at the root of the MB canal (Figure 2).

Figure 1. Initial X-Ray.

Based on the clinical, subjective, and imaging evaluations, a diagnosis of chronic apical periodontitis was established for tooth 2.6. Following these investigations, the decision was made to perform conservative orthograde endodontic retreatment involving chemo-mechanical canal preparation and subsequent root canal obturation.

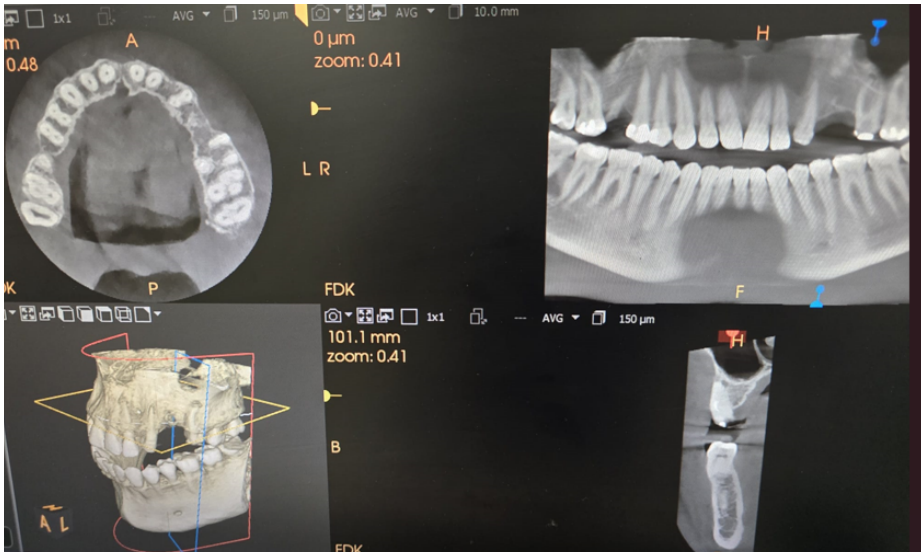

Figure 2. CBCT performed after dental bridge removal.

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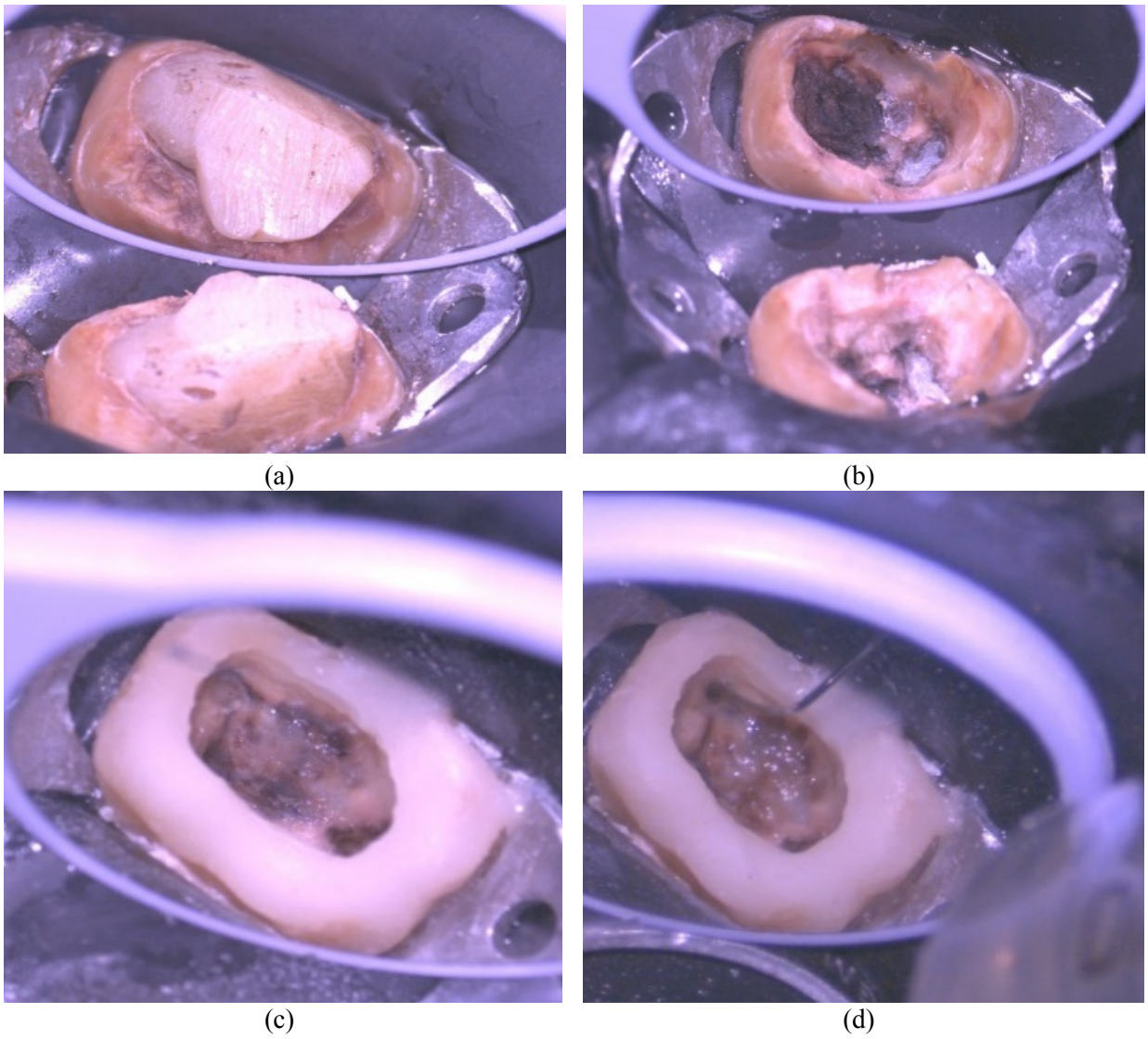
The endodontic retreatment was performed on tooth number 26 following the steps in the protocol explained in material and methods section (Figures 3, 4, 5).



(a) (b) (c) (d)

Figure 3. (a) Rubberdam isolation; (b) Removal of obturation and decay; (c) Build-up; (d) Finding MB2.

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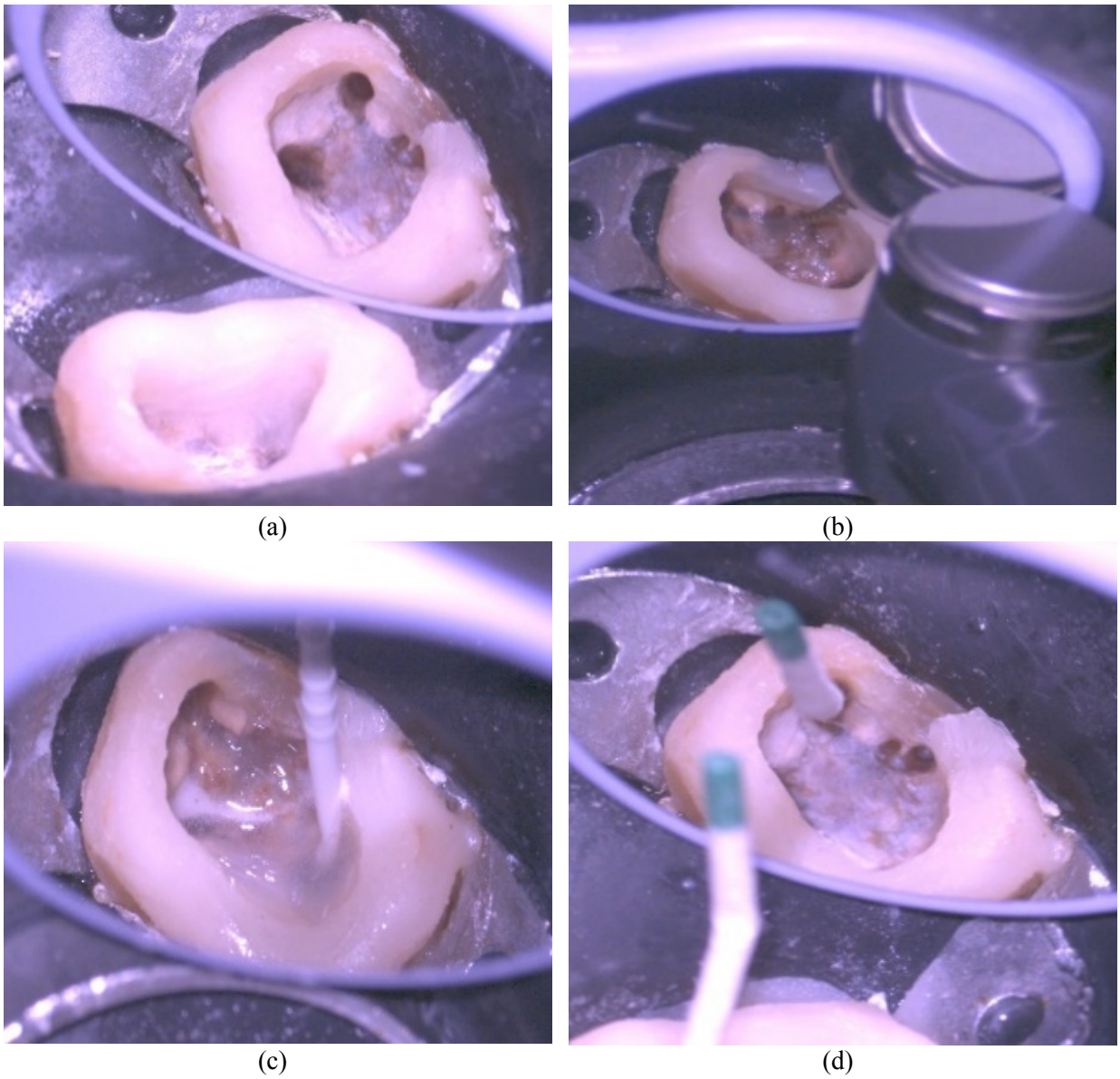

Figure 4. (a) Retreatment of main canals; (b) Shaping the MB2; (c) Activating the irrigant; (d) Drying.

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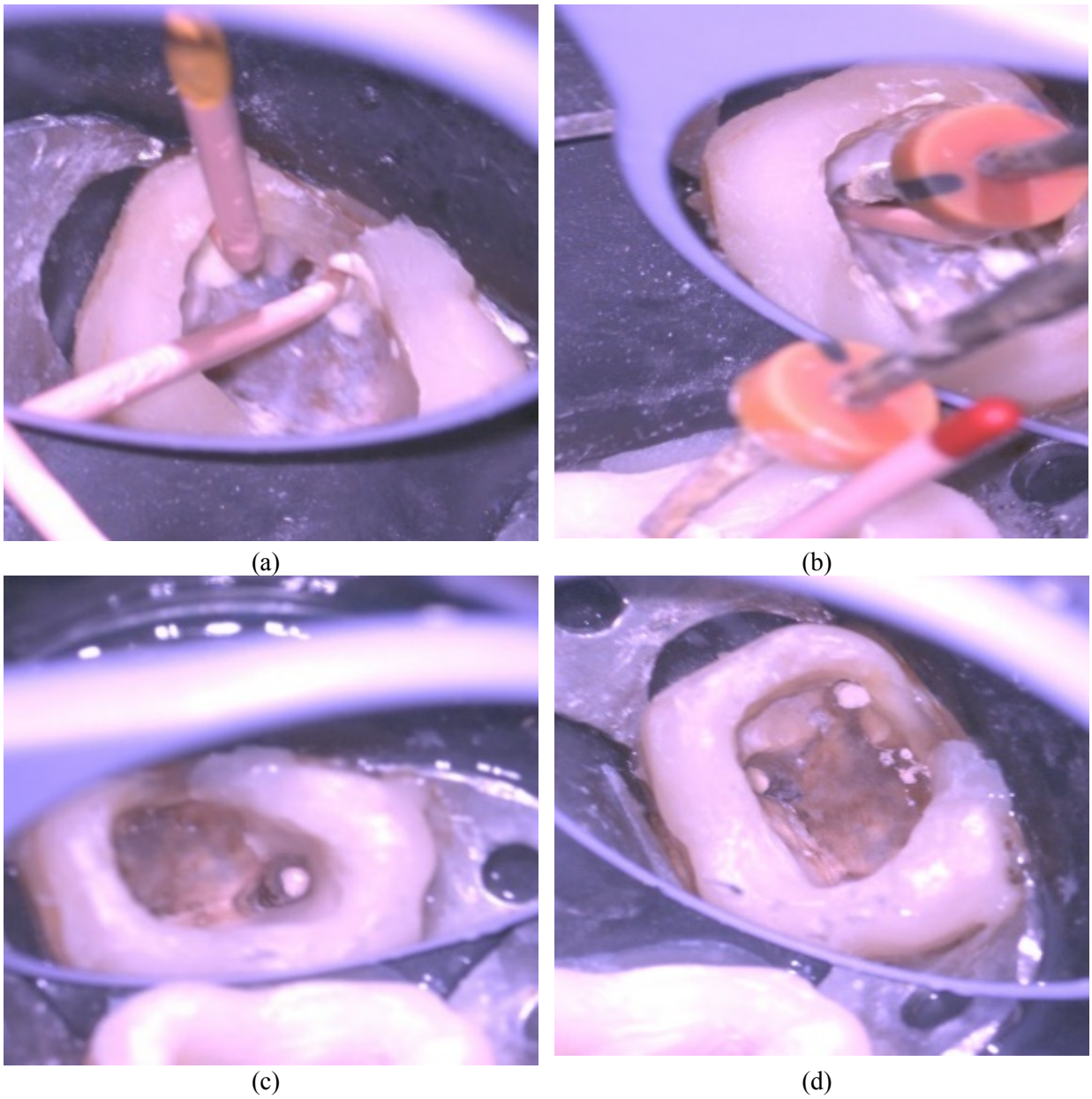

Figure 5. (a) Guttapercha master cones and sealer; (b) Down-pack; (c) Palatal root partially obturated prepared for fiberpost; (d) Root canal obturation.

After the endodontic retreatment it was performed a control X-ray (Figure 6).

Case no 2: A 59-year-old female presented to the clinic, reporting discomfort, food retention, and fetid halitosis in the upper right molar region, where a full-coverage crown was noted. The patient mentioned infrequent use of the affected area during mastication due to occasional discomfort.

A clinical examination, including inspection, palpation, and axial percussion, revealed the following findings:

- Slight congestion of the mucosa in the upper right vestibule near the first molar region.

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- A poorly adapted full-coverage crown with marginal secondary caries.
- Axial and transverse percussion tests showed moderate sensitivity in tooth 1.7.
- Palpation of the vestibule at the apex of tooth 1.7's root was painful, though no fluctuation was detected.
- Thermal vitality tests (cold and hot) were not performed due to the tooth having undergone previous endodontic treatment.

A three-dimensional radiographic examination (Figure 7) revealed:

- A poorly adapted full-coverage crown with marginal secondary caries.
- A previously performed endodontic treatment with incomplete and non-homogeneous canal obturation.
- The presence of an ill-defined radiolucent area around the distobuccal, mesiobuccal, and palatal roots.

Figure 6. Control X-Ray.

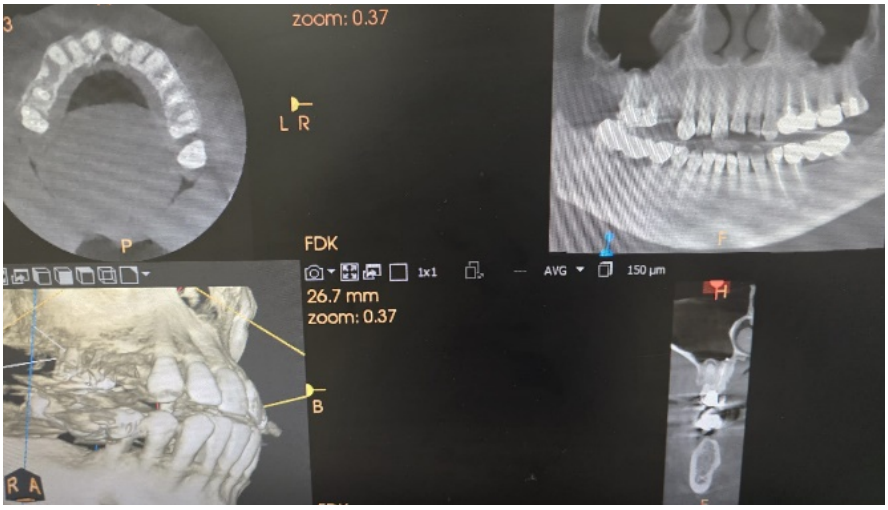

Figure 7. The initial CBCT.

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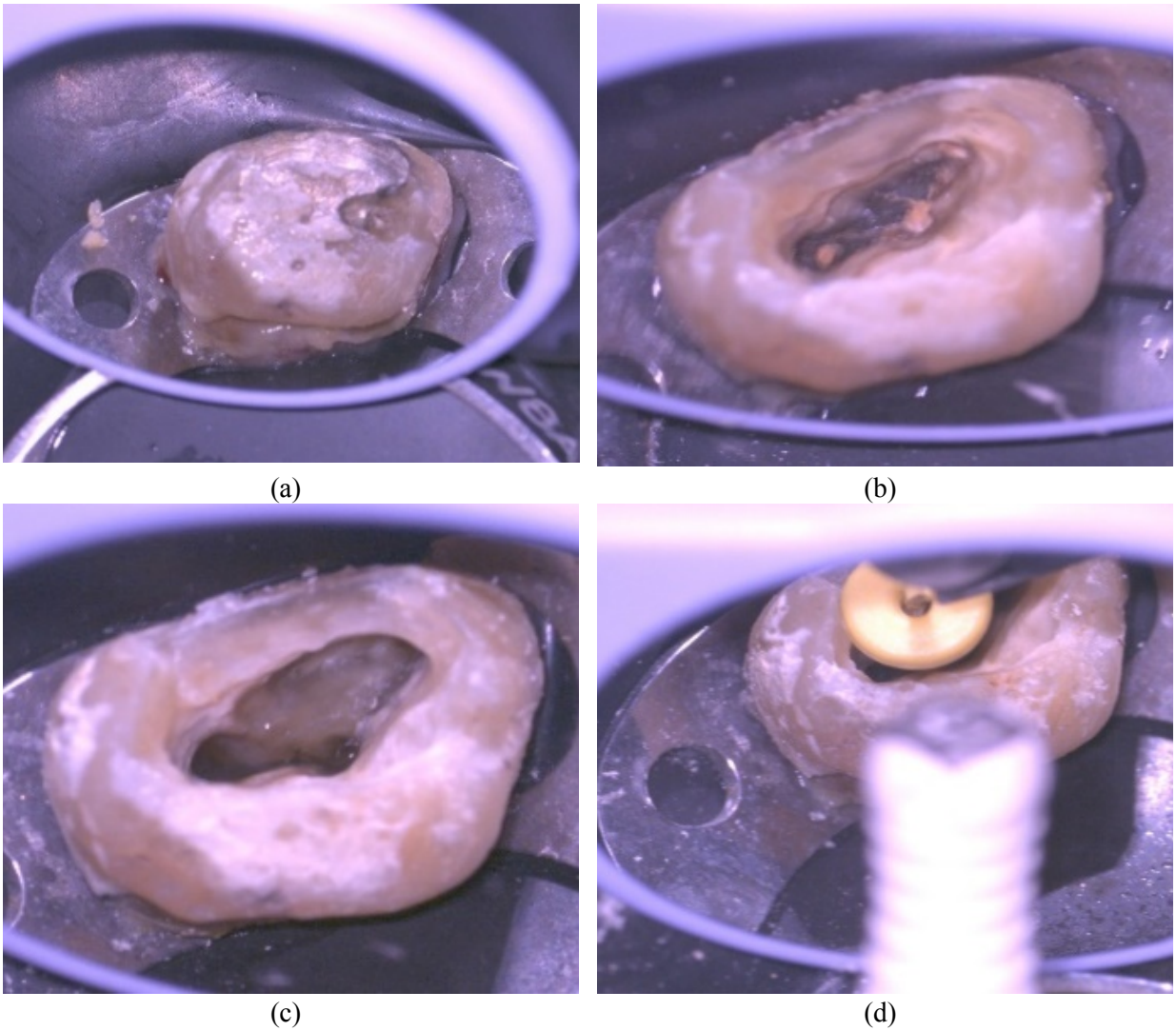
Based on the clinical, subjective, and imaging evaluations, a diagnosis of exacerbated chronic apical periodontitis was established for tooth 1.7. Following the investigations, the decision was made to perform conservative orthograde endodontic retreatment (Figure 8), involving shaping root canals followed by obturation (Figure 9). In the end, a X-ray for checking the quality of endodontic obturation was performed (Figure 10).



(a) (b)

(c) (d)

Figure 8. (a) Rubber dam isolation; (b) Removal of coronal obturation; (c) Removal of root canal obturation; (d) Determination of the working length.

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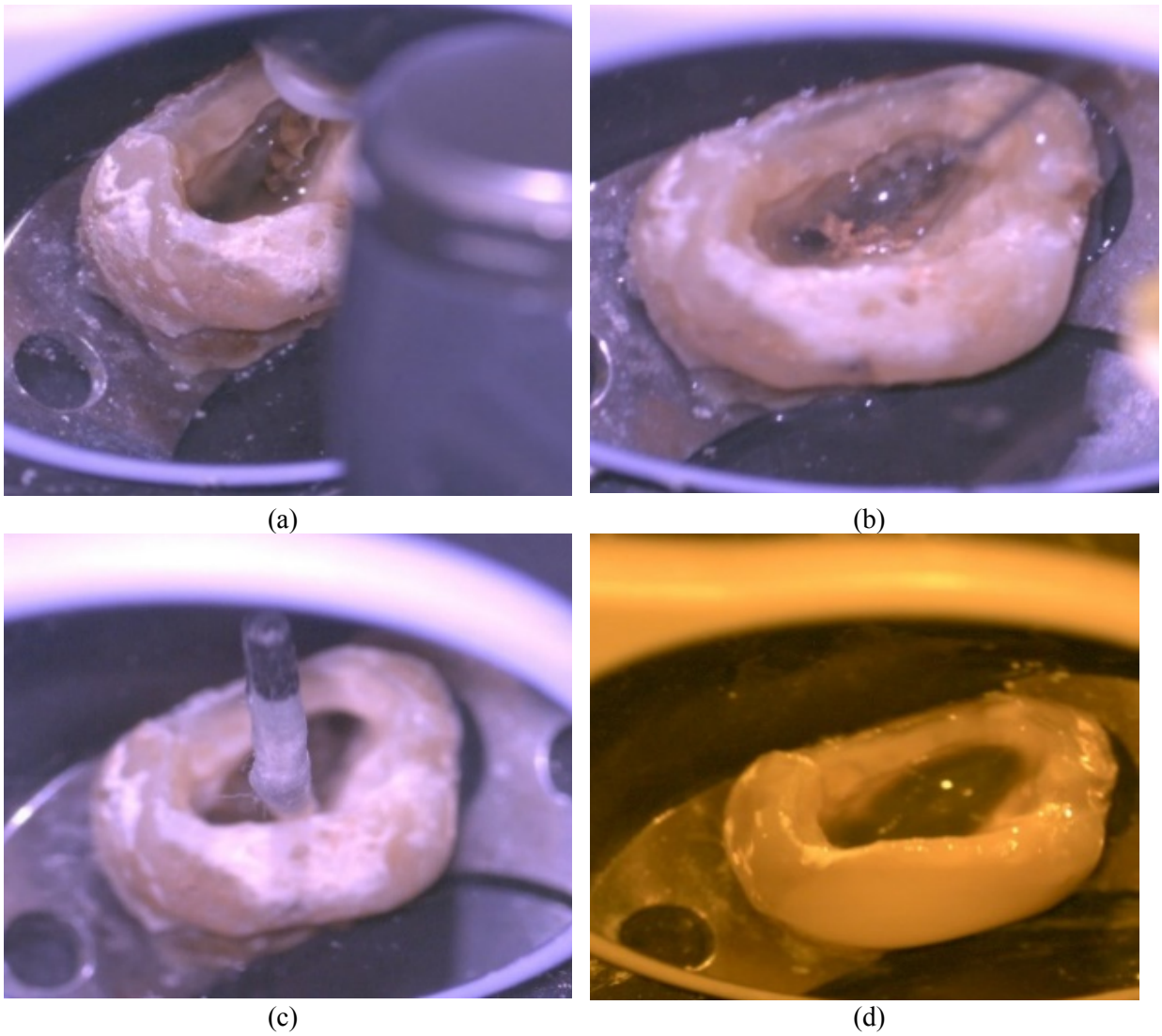

Figure 9. (a) Rotary shaping; (b) Endodontic irrigation; (c) Drying the canals using paper points; (d) Root canal obturation and coronal obturation with coloured flowable.

Figure 10. Control X-Ray.

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Case no 3: A 60-year-old female presented to the Endodontics Clinic, complaining of pain during mastication in the lower right premolar region, where a tooth was noted to be prepared as a post and a coronal occlusal filling was present. The patient reported having had acute episodes in the past and that the tooth underwent conservative orthograde endodontic treatment 9 months ago. The affected area was used infrequently for mastication, with occasional discomfort. A clinical and objective examination, including inspection, palpation, and axial percussion, revealed:

- Mild congestion of the mucosa in the lower right vestibule near the first premolar.
- An occlusal coronal filling with marginal secondary caries.
- Axial and transverse percussion tests revealed pronounced sensitivity at tooth 4.4.
- Palpation at the vestibule near the apex of tooth 4.4 was painful, but no fluctuation was detected.
- Thermal vitality tests (cold and hot) were not performed, as the tooth had undergone previous endodontic treatment.
- A three-dimensional radiographic examination (Figure 11) revealed:
- An occlusal coronal filling with poor adaptation and marginal secondary caries.
- A previously performed endodontic treatment with incomplete and non-homogeneous canal obturation.
- An ill-defined radiolucent area at the apical region.
- The presence of a missed canal, the lingual canal.

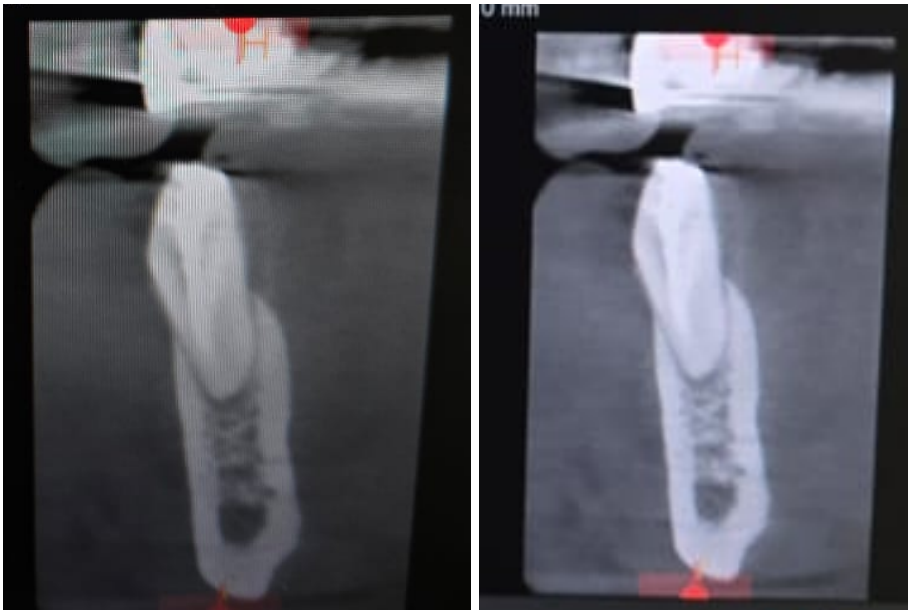

Figure 11. The initial CBCT.

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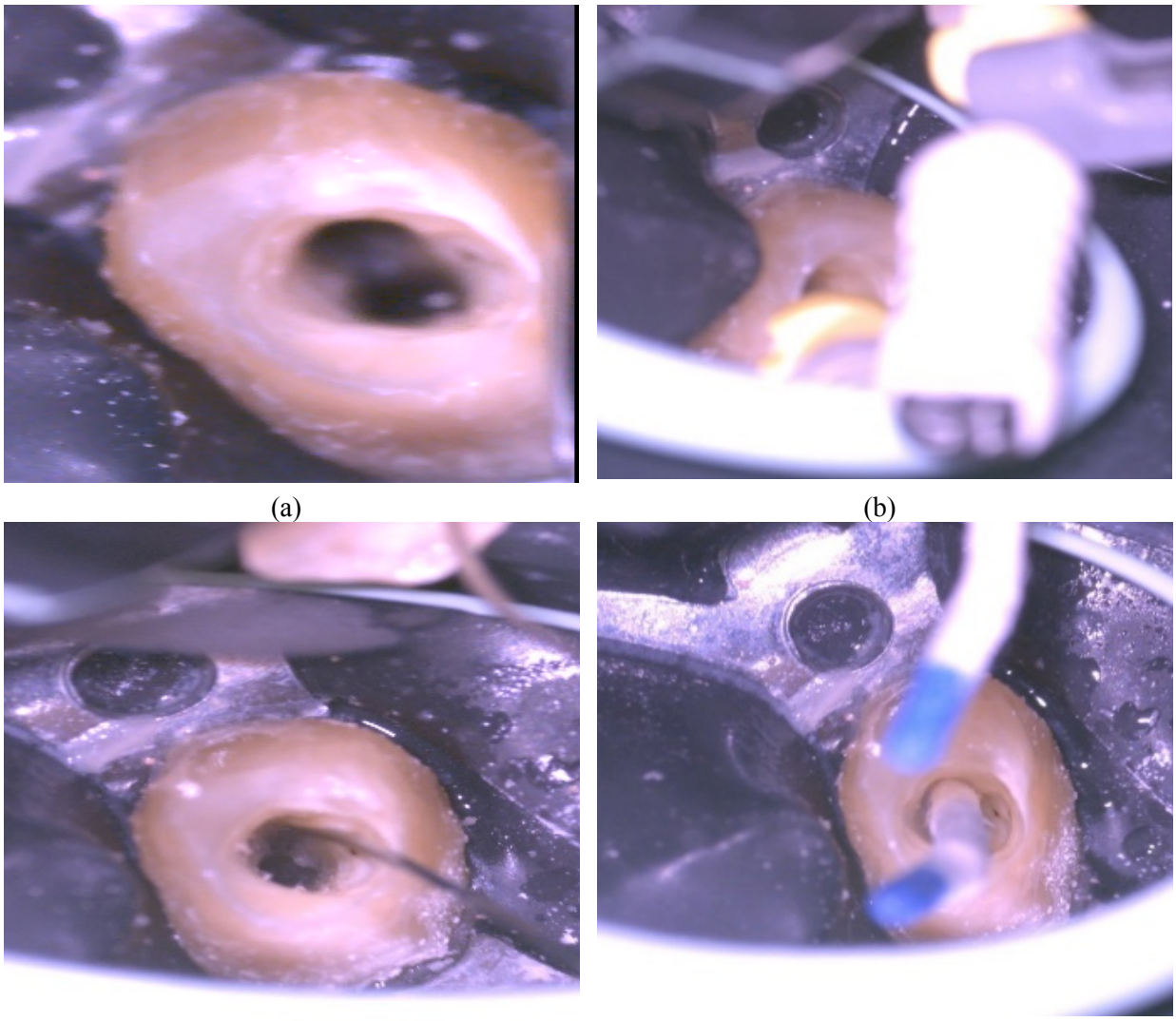
Based on the clinical, subjective, and imaging findings, a diagnosis of exacerbated chronic apical periodontitis was established for tooth 4.4. Following the investigations, the decision was made to perform conservative orthograde endodontic retreatment, involving chemo-mechanical canal preparation (Figure 12) followed by root canal obturation (Figure 13). In the end, the endodontic treatment was verified using a X-Ray (Figure 14).



(a) (b)

(c) (d)

Figure 12. (a) Finding the lingual canal; (b) Determing the working length; (c) Irrigation; (d) Drying.

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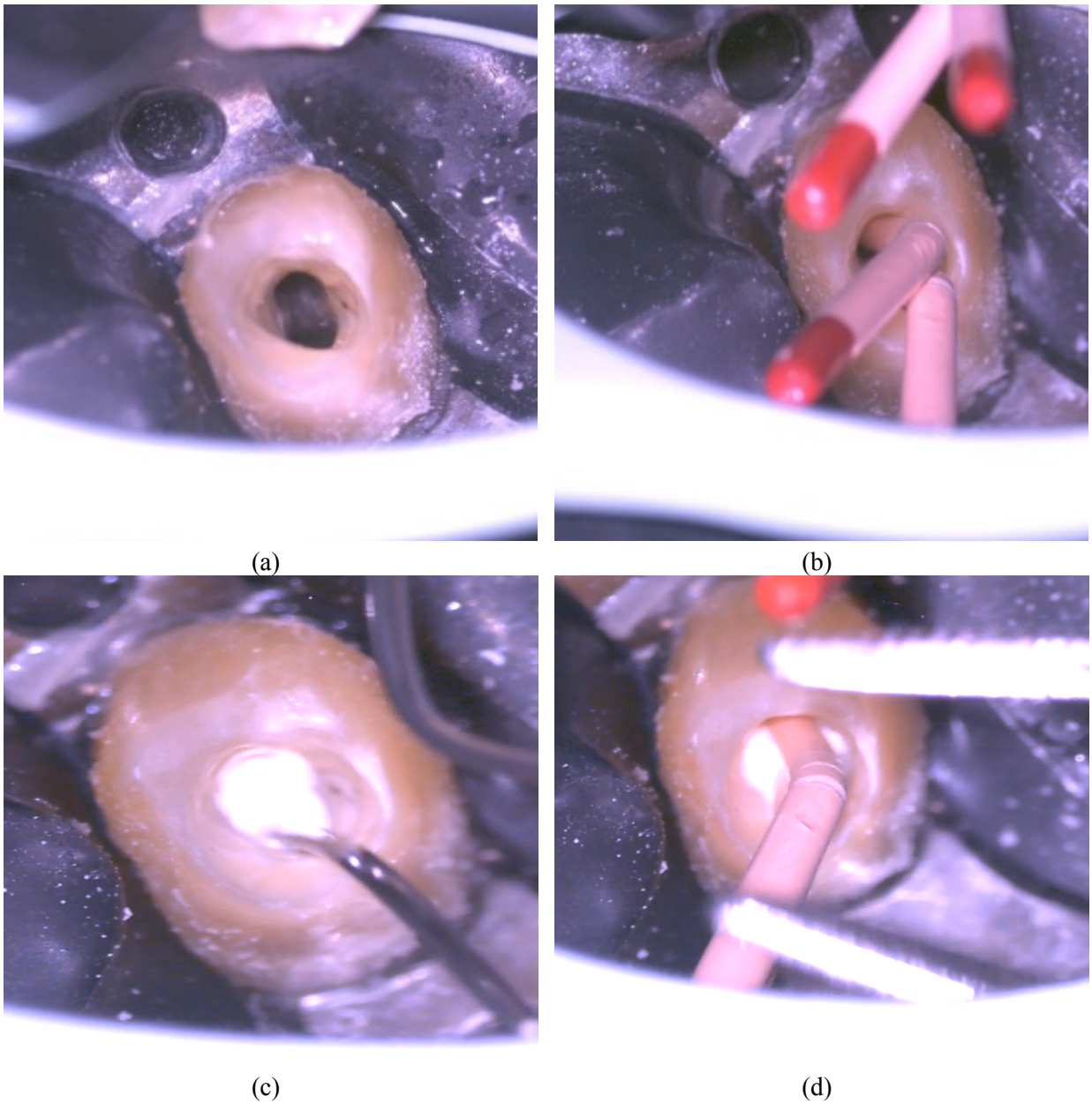

Figure 13. (a) Two dried canals; (b) Fitting master cones; (c) Introducing bioceramic sealer; (d) Introducing the gutta-percha cone.

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Figure 14. Control X-Ray.

4. Discussions

The lower healing rate of orthograde retreatments compared to primary endodontic treatments has been well documented in the literature [14], with persistent microbial infection being one of the significant causes of failure [12]. Research studies emphasize the advantages of orthograde retreatments over apical surgery and show that late failures are more likely to occur in teeth that have undergone surgical treatment. A slower healing dynamic might explain the higher success rate over time in teeth that were not retreated orthograde [15].

In our study, 33.3% from the evaluated teeth exhibited periapical radiolucencies. Holland et al. [16] concluded that in the absence of periradicular lesions, the orthograde retreatment success rate is higher. In contrast, in cases where lesions were present, the success rate ranged from a minimum of 31.8% to a maximum of 85% [16]. Friedman et al. [17] showed a success rate of over 90% for orthograde endodontic retreatment in teeth without periapical lesions, suggesting that in cases where infection is not present and the procedure is performed by specialists, the success rate is high. Sjogren et al. [14], performing endodontic retreatments on 173 roots in the absence of periapical lesions, achieved a success rate of 98%. If a periapical lesion is present before the start of the endodontic retreatment, the success rate can be estimated at no more than 70% [17].

Endodontic retreatment repeats the stages of primary endodontic treatment using an orthograde approach, with the goal of cleaning the root canals of irritants, most of the apical microorganisms that survived the previous treatment or infiltrated post-therapy. Therefore, endodontic retreatment aligns with the biological rationale of canal therapy and is preferred whenever possible [18]. Nonsurgical endodontic retreatment can be divided into two phases: removal of the root canal filling and re-instrumentation of the endodontic system [19], with various retreatment techniques being proposed, the most recent of which are performed using rotary nickel-titanium instruments [20].

Some studies conducted over time have highlighted the presence of persistent apical periodontitis in endodontically treated teeth

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in 45% of cases [21, 22]. The cause of persistent apical periodontitis is mainly attributed to microorganisms that survived the primary endodontic treatment. This issue can be resolved through conservative orthograde endodontic retreatment [23].

The cases treated in this study were diagnosed with apical periodontitis, with previous endodontic treatments being technically deficient; thus, conservative orthograde retreatments were performed as the first approach to resolve the pathology. The etiology of endodontic infections is bacterial, so the removal of bacteria and secondary byproducts from the endodontic system through appropriate chemo-mechanical treatment is crucial for a successful long-term outcome [24, 25].

Ricucci concluded that persistent intraradicular bacteria should be considered the main cause and reason why endodontic retreatments are necessary [22]. For the reasons mentioned above, missed anatomy is one of the most common causes of failure in primary endodontic treatment [26, 27]. Mashyakhy et al. discovered that the frequency of apical periodontitis in teeth treated with missed canals was about 90%, while Baruwa et al. found a frequency of 82.6%, and Costa et al. 98% [28-30].

According to the literature, missed canals predominantly affect maxillary first molars, particularly the mesio-buccal 2 (MB2) canal, followed by mandibular first molars, especially the second canal in the distal roots [31,32]. Additionally, a supplemental mesial canal, the middle mesial canal, is frequently found in lower molars, with prevalence ranging from 0.26% to 53.8%. For incisors (central, lateral) and canines, the percentage was 20.4%, 25.3%, and 5.9%, respectively, with the real prevalence closely linked to the ethnicity of the population, as described by Dhuldhoya et al. [33, 34].

For example, in our study in the first presented case, an orthograde conservative endodontic retreatment was performed on the upper first molar, where the MB2 canal was missed, prepared, and obturated. To identify the missed canal, three-dimensional radiographs, magnification, adequate lighting, endodontic probes (DG 16), and ultrasound were used, with the color and consistency of the dentin aiding in locating the entry orifice. n the third presented case, the failure of the primary treatment and the persistence of pathology were attributed to the omission of the lingual canal. With the technology described, the canal was located and detached from the main canal at an acute angle, thereby preventing the source of infection. Clinicians begin endodontic treatments by observing the anatomy of the root canals using radiographs. The presence of internal anatomical variations and anomalies is not uncommon [35]. Among these variations, the incidence of middle mesial canals ranges from 0.5% to 15% [36, 37], with a high frequency of intercanal isthmuses constituting an additional step in the chemo-mechanical debridement procedures [38].

A limited understanding of the tooth's anatomy, the complexity of the canal configuration, or procedural errors (such as inadequate cavity design) can contribute to the omission of a canal in a treated tooth. Missed canals are potential microbial reservoirs and a primary cause of persistent

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apical periodontitis [39]. Endodontic literature provides clear evidence supporting that nonsurgical endodontic retreatment is performed on teeth with many missed canals after initial endodontic treatment. Missed canals are identified in 42% of teeth that undergo nonsurgical endodontic retreatment [40]. A thorough understanding of anatomy is necessary to provide information on where to search for the canal entry. Proper visualization of the root canal anatomy is crucial, and at least two periapical radiographs with different angulations are needed to achieve this. For a complete understanding of the three-dimensional anatomy, CBCT imaging is used [41].

Magnification tools such as loupes and the operating microscope significantly enhance visibility, improving accessory canal identification [42]. Other studies have highlighted the importance of ultrasonic tips, resulting in better procedural quality during endodontic retreatments [43]. In all the cases presented in this study, endodontic retreatments were performed under magnification as a standard in endodontics, emphasizing every detail in the process, including difficult-to-reach areas, ensuring optimal working conditions and excellent visual control.

Three-dimensional imaging is more sensitive in detecting periapical lesions than two-dimensional radiographs, as demonstrated by Aminoshariae et al. Cone beam computed tomography (CBCT) doubles the chance of detecting periapical lesions compared to two-dimensional periapical radiographs [44]. For diagnosing the presented cases (cases 1, 2, 3), besides a thorough clinical examination, we used complementary diagnostic tools such as retroalveolar radiographs with the paralleling technique. Superior CBCT imaging was necessary, in terms of specificity and diagnostic sensitivity, to increase the accuracy of periapical status assessment. Studies like Bhatt et al. (2021) have recently investigated the impact of CBCT on initial diagnosis and clinical decision-making compared to conventional radiographs in endodontic treatments. They concluded that the additional information obtained from CBCT images led to changes in initial diagnoses and treatment plans in 59% of 96 cases (61%) and 64 of 96 cases (66%) [45]. Ee et al. drew a similar conclusion. They reported that implementing the three-dimensional radiographic examination led to changes in the treatment plan in approximately 62% of cases [46]. Several studies have evaluated the technical quality of root canal obturations radiographically, suggesting that this can affect the outcome of endodontic treatment [47].

A study of the extruded root canal filling material after primary endodontic treatment highlighted its association with unsatisfactory technical quality and noted that over-instrumentation favored root canal overfilling [48]. Overfilling can delay healing or even predispose to treatment failure. Teeth that underwent orthograde retreatment with adequate canal obturations showed higher success rates [49].

In our study 43.3 of the retreated teeth had previous infiltrated obturations. Poor quality root canal obturation in the primary treatment predisposes to endodontic failure, with studies showing that their compatibility with the physicochemical characteristics of

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various microorganisms' surfaces allows bacterial adherence and biofilm formation. Furthermore, microorganisms surviving the chemo-mechanical treatment may attach to the filling materials. In one study, nine bacterial species were isolated from filling materials, underlining the microbiological importance of additional sampling of obturation material in persistent infections to enhance understanding of the failure's etiology and healing process [50].

In all the cases retreated in this study, signs of incomplete previous root canal obturation were observed, which is a poor prognostic factor for primary endodontic treatments and maintaining periapical inflammatory responses. Removing previous root canal filling materials is critical to ensure proper disinfection and adequate root obturation, addressing the cause of primary endodontic treatment failure. Gutta-percha remains the most commonly used filling material, combined with sealers of variable chemical composition, and is applied through various obturation techniques, which can be categorized into "cold" and "hot" techniques [51].

The warm vertical condensation of gutta-percha in the root canal system results in its difficult removal when orthograde endodontic retreatment is necessary. Therefore, several solvents have been proposed to soften the obturation materials, including chloroform, eucalyptus oil, xylene/xylol, orange oil, methylene chloride, and halothane. However, concerns about their cytotoxicity remain [52]. Specialists have demonstrated that the use of solvents during retreatment can lead to residual gutta-percha and filling material on the root canal walls and inside the dentinal tubules, potentially compromising the disinfection of the endodontic system and threatening the outcome of the retreatment [53].

In all the cases treated in this study, orange oil was used as a solvent to soften the gutta-percha and facilitate the reaching of working length with rotary instruments using the Crown-down technique. Ultrasonic activation with flexible endodontic files allowed the detachment of fragments adhering to the canal walls, which were then removed through abundant irrigation. Regarding gutta-percha removal by the most common mechanical technique [51], both manual and rotary instruments have been proposed, with NiTi instruments being more effective and requiring less operating time, resulting in fewer residual remnants in the endodontic system [51,52].

The long-term success of endodontic retreatments is mainly dependent on the correct restoration of the coronal part of the tooth [54]. As previously mentioned, a tooth undergoing endodontic treatment requires a coronal crown. The clinician must decide whether to access the root canal through the existing restoration or remove it. Accessing through the coronal restoration can be risky, and uncementing the crown may lead to complications, including the need to remake the crown [55]. Minimally invasive access cavities are becoming more commonly used, but in retreatment cases, expanding the preexisting access cavity may be necessary to detect missed canals. Additionally, the presence of prefabricated crowns requires using ultrasonic tips to remove them. Alternating between water and air is needed

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to avoid overheating and damaging the periodontal ligament [56-58].

Endodontic pathology has a bacterial etiology, and any procedure that can enhance the antimicrobial activity of irrigants without causing adverse effects is recommended [59]. Based on available studies, the use of sodium hypochlorite (NaOCl) and freshly prepared EDTA, activated with ultrasound for several cycles (1 minute for each irrigant) during the final irrigation phase, remains the standard for irrigation protocols [168].

In the reported cases, we used sonic activation of the irrigants (Eddy device)or the ultrasonic activation. Sodium hypochlorite at 5.25% and EDTA at 17% concentration were irrigants, with a special syringe and needle with side vents as the delivery system. The success of nonsurgical endodontic retreatment depends on several factors, and the evaluation of healing rates relies on clinical signs, symptoms, and radiographs [54].

The success of endodontic treatment is often evaluated by the presence or absence of clinical symptoms and the status of periapical radiolucency. Key indicators for retreatment include poor root canal obturation, with correct obturation within 0–2 mm of the radiographic apex, and loss of coronal sealing, both of which increase the likelihood of failure. Periapical radiolucency and flare-ups between sessions are associated with lower success rates [13,60,61].

The quality of the primary endodontic treatment influences the success of endodontic retreatment. Factors such as fractured instruments and root perforations can complicate retreatment and negatively impact clinical and radiographic outcomes [50]. However, some studies suggest fractured instruments may not significantly affect periapical healing [62]. Morphological changes in the root canal during the initial treatment can also affect the outcome of retreatment [50]. Ultimately, symptoms, periapical lesions, and defective coronal restoration are considered primary reasons for undertaking endodontic retreatment, which aligns with the criteria used in the study discussed [50].

5. Conclusions

In cases of primary orthograde endodontic treatment failure, modern endodontic management emphasizes repeating a conservative orthograde approach, reserving surgical endodontic intervention only as a last resort.

Coronal restoration plays a significant role before initiating orthograde retreatment. Whether to remove or preserve the restoration depends on specific conditions, each presenting distinct advantages and drawbacks.

Anatomical variations significantly increase the likelihood of failure if unrecognized and improperly addressed. Comprehensive knowledge of root canal anatomy and its potential variations is essential for clinicians to minimize treatment failures and the need for subsequent retreatments.

Proper interpretation of periapical radiographs is critical. Intermediary radiographs are needed when complications like fractured instruments, perforations, or missed canals are suspected.

Despite risks such as dentinal wall undermining, canal wall perforations, ledge formation, and instrument fractures,

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orthograde retreatment is generally a predictable treatment option with high success rates.

Orthograde endodontic retreatment achieves a high success rate, and involving specialists in its practice reduces procedural errors. Incorporating advanced technologies and modern materials further minimizes inaccuracies in retreatment procedures.

References

1. Altunbas D, Kutuk B, Toyoglu M, Kutlu G, Kustarci A, Er K. Reciproc versus Twisted file for root canal filling removal: assessment of apically extruded debris. Journal of Istanbul University Faculty of Dentistry. 2016; 50(2): 31-37.
2. American Association of Endodontists, 2020. Glossary of Endodontic Terms. Updated March 2020.
3. Zuolo M, Kherlakian D, De Mello Jr J, Carvalho M, Fagundes M. Reintervention in Endodontics. Batavia: Quintessence, 2014.
4. de Chevigny C, Dao TT, Basrani BR, et al. Treatment outcome in endodontics: the Toronto study—phase 4: initial treatment. J Endod. 2008;34:258–63.
5. Ng YL, Mann V, Rahbaran S, Lewsey J, Gulabivala K. Outcome of primary root canal treatment: systematic review of the literature—part 2. Influence of clinical factors. Int Endod J. 2008;41:6–31.
6. Salehrabi R, Rotstein I. Endodontic treatment outcomes in a large patient population in the USA: an epidemiological study. J Endod. 2004;30:846–50.
7. Torabinejad M, Anderson P, Bader J, et al. Outcomes of root canal treatment and restoration, implant-supported single crowns, fixed partial dentures, and extraction without replacement: a systematic review. J Prosthet Dent. 2007;98:285–311.
8. Ruddle CJ. Microendodontic nonsurgical retreatment, in: Microscopes in Endodontics. Dent Clin North Am. 1997;41(3):429–54.
9. Ruddle CJ. Nickel-titanium rotary instruments: current concepts for preparing the root canal system. Aust Endod J. 2003;29(2):87–98.
10. Rios M, Villela AM, Cunha RS, Velasco RC, De Martin AS, Kato AS, Bueno CE. Efficacy of 2 reciprocating systems compared with a rotary retreatment system for gutta-percha removal. J Endod. 2014;40(4):543–6.
11. Ashley M, Harris I. The assessment of the endodontically treated tooth. Dent Update. 2001;28:247–52.
12. Tabassum S, Khan FR. Failure of endodontic treatment: the usual suspects. Eur J Dent. 2016;10:144–7.
13. European Society of Endodontology. Quality guidelines for endodontic treatment: consensus report of the European Society of Endodontology. Int Endod J. 2006;39(12):921–30.
14. Sjögren U, Hagglund B, Sundqvist G, Wing K. Factors affecting the long-term results of endodontic treatment. J Endod. 1990;16:498–504.
15. Torabinejad M, Corr R, Handysides R, Shabahang S. Outcomes of nonsurgical retreatment and endodontic surgery: a systematic review. J Endod. 2009;35(7):930–7.
16. Holland R, Valle GF, Taintor JF, Ingle JI. Influence of bony resorption on endodontic treatment. Oral Surg Oral Med Oral Pathol. 1983;55(2):191–203. Ashley, M. and Harris, I., 2001. The assessment of the endodontically treated tooth. Dental Update, 28, pp.247-252.
17. Friedman S. Treatment outcome and prognosis of endodontic therapy. In: Ørstavik D, Pitt Ford TR, editors. Essential

Endodontology. London: Blackwell Scientific; 1998. p. 367–401.
18. Mărgărit R, Andrei OC. Endodontic retreatment in case of failure: case report. Rev Med Chir Soc Med Nat Iasi. 2011;115:944–8.
19. Schirrmeister JF, Wrbas KT, Schneider FH, Altenburger MJ, Hellwig E. Effectiveness of a hand file and three nickel-titanium rotary instruments for removing gutta-percha in curved root canals during retreatment. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2006;101:542–7.
20. Flávio R, Alves F, Rôças IN, Provenzano JC, Siqueira JS Jr. Removal of the previous root canal filling material for retreatment: implications and techniques. J Clin Med. 2022;12(20):10217.
21. Dugas NN, Lawrence HP, Teplitsky PE, Pharoah MJ, Friedman S. Periapical health and treatment quality assessment of root-filled teeth in two Canadian populations. Int Endod J. 2003;36(3):181–92.
22. Kirkevang LL, Horsted-Bindslev P, Ørstavik D, Wenzel A. Frequency and distribution of endodontically treated teeth and apical periodontitis in an urban Danish population. Int Endod J. 2001;34:198–205.
23. Friedman S, Mor C. The success of endodontic therapy—healing and functionality. J Calif Dent Assoc. 2004;32(6):493–503.
24. Ricucci D, Siqueira JF Jr, Bate AL, Pitt Ford TR. Histologic investigation of root canal-treated teeth with apical periodontitis: a retrospective study from twenty-four patients. J Endod. 2009;35(4):493–502.25.
25. Ricucci D, Siqueira JF Jr. Biofilms and apical periodontitis: study of prevalence and association with clinical and histopathologic findings. J Endod. 2010;36(8):1277-1288.
26. Nair PN. On the causes of persistent apical periodontitis: a review. Int Endod J. 2006;39:249-281.
27. Witherspoon DE, Small JC, Regan JD. Missed canal systems are the most likely basis for endodontic retreatment of molars. Tex Dent J. 2013;130(2):127-139.
28. Mashyakhy M, Jabali A, Alabsi FS, AbuMelha A, Alkahtany M, Bhandi S. Anatomical evaluation of mandibular molars in a Saudi population: an in vivo cone-beam computed tomography study. Int J Dent. 2021;2021:5594464.
29. Baruwa AO, Martins JNR, Meirinhos J, et al. The influence of missed canals on the prevalence of periapical lesions in endodontically treated teeth: a cross-sectional study. J Endod. 2020;46(1):34-39.
30. Costa F, Pacheco-Yanes J, Siqueira JF Jr, et al. Association between missed canals and apical periodontitis. Int Endod J. 2019;52(4):400-406.
31. Colakoglu G, Kaya Buyukbayram I, Elcin MA, Garip Berker Y, Ercalik Yalcinkaya S. Association between second mesiobuccal canal and apical periodontitis in retrospective cone-beam computed tomographic images. Aust Endod J. 2023;49(1):20-26.
32. Peña-Bengoa F, Cáceres C, Niklander SE, Meléndez P. Association between second mesiobuccal missed canals and apical periodontitis in maxillary molars of a Chilean subpopulation. J Clin Exp Dent. 2023;15(3):173-176.
33. Martins JNR, Marques D, Leal Silva EJN, Caramês J, Mata A, Versiani MA. Influence of demographic factors on the prevalence of a second root canal in mandibular anterior teeth - A systematic review and meta-analysis of cross-sectional studies using cone beam computed tomography. Arch Oral Biol. 2020;116:104749.
34. Dhuldhoya DN, Singh S, Podar RS, Ramachandran N, Jain R, Bhanushali N. Root canal anatomy of human permanent mandibular incisors and mandibular canines:

A systematic review. J Conserv Dent. 2022;25(3):226-240.
35. Hasan M, Fahad Umer F. Endodontic retreatment of a mandibular first molar with five root canal systems: an important clinical lesson. BMJ Case Rep. 2014;2014:bcr2013202066.
36. Baugh D, Wallace J. Middle mesial canal of the mandibular first molar: a case report and literature review. J Endod. 2004;30:185-186.
37. Deepalakshmi M, Anupama R, Khan HS, et al. The mandibular first molar with three canals in the mesial root—A case report. J Clin Diagn Res. 2013;7:601-603.
38. Deepalakshmi M, Karumaran CS, Miglani R, et al. Independent and confluent middle mesial root canals in mandibular first molars. Case Rep Dent. 2012;2012:103125.
39. Wolcott J, Ishley D, Kennedy W, Johnson S, Minnich S, Meyers J. A five-year clinical investigation of second mesiobuccal canals in endodontically treated and retreated maxillary molars. J Endod. 2005;31:2624.
40. Hoen MM, Pink FE. Contemporary endodontic retreatments: An analysis based on clinical treatment findings. J Endod. 2002;28:834-836.
41. Patel S, Brown J, Semper M, Abella F, Mannocci F. European Society of Endodontology position statement: use of cone beam computed tomography in Endodontics: European Society of Endodontology (ESE) developed by. Int Endod J. 2019;52(12):1675-1678.
42. Carr GB, Murgel CA. The use of the operating microscope in endodontics. Dent Clin North Am. 2010;54(2):191-214.
43. Plotino G, Pameijer CH, Grande NM, Somma F. Ultrasonics in endodontics: a review of the literature. J Endod. 2007;33(2):81-95.
44. Aminoshariae A, Kulild JC, Syed A. Cone-beam computed tomography compared with intraoral radiographic lesions in endodontic outcome studies: A systematic review. J Endod. 2018;44(11):1626-1631.
45. Bhatt M, Coil J, Chehroudi B, Esteves A, Aleksejuniene J, MacDonald D. Clinical decision-making and importance of the AAE/AAOMR position statement for CBCT examination in endodontic cases. Int Endod J. 2021;54(1):26-37.
46. Ee J, Fayad MI, Johnson BR. Comparison of endodontic diagnosis and treatment planning decisions using cone-beam volumetric tomography versus periapical radiography. J Endod. 2014;40(7):910-916.
47. Ribeiro DM, Réus JC, Felippe WT, Pacheco-Pereira C, Dutra KL, Santos JN, et al. Technical quality of root canal treatment performed by undergraduate students using hand instrumentation: A meta-analysis. Int Endod J. 2018;51(3):269-283.
48. Gutierrez JH, Brizuela C, Villota C. Human teeth with periapical pathosis after overinstrumentation and overfilling of the root canals: a scanning electron microscopic study. Int Endod J. 1999;32(1):40-48.
49. Sjögren U, Hagglund B, Sundqvist G, Wing K. Factors affecting the long-term results of endodontic treatment. J Endod. 1990;16:498-504.
50. Signor B, Blomberg LC, Kopper PMP, Augustin PAN, Rauber MV, Rodrigues GS, Scarparo RK. Root canal retreatment: A retrospective investigation using regression and data mining methods for the prediction of technical quality and periapical healing. J Appl Oral Sci. 2021;29:e20200799.
51. Duncan HF, Chong BS. Removal of root filling materials. Endod Topics. 2008;19(1):33-57.
52. Ajina MA, Shah PK, Chong BS. Critical analysis of research methods and experimental models to study removal of root filling materials. Int Endod J. 2022;55(1):119-153.

53. Horvath SD, Altenburger MJ, Naumann M, Wolkewitz M, Schirrmeister JF. Cleanliness of dentinal tubules following gutta-percha removal with and without solvents: a scanning electron microscopic study. Int Endod J. 2009;42(11):1032-1038.
54. Zanza A, Reda R, Testarelli L. Endodontic orthograde retreatments: challenges and solution. Clin Cosmet Investig Dent. 2023;15:245-265.
55. Roda RS. Approaches to nonsurgical root canal retreatment. J Multidiscip Care Decis Dent. 2018:890-952.
56. Budd JC, Gekelman D, White JM. Temperature rise of the post and on the root surface during ultrasonic post removal. Int Endod J. 2005;38:705-711.
57. Dominici JT, Clark S, Scheetz J, Eleazer PD. Analysis of heat generation using ultrasonic vibration for post removal. J Endod. 2005;31:301-303.
58. Schwartz RS, Robbins JW. Post placement and restoration of endodontically treated teeth: a literature review. J Endod. 2004;30:289-301.
59. Boutsioukis C, Noula G, Lambrianidis T. Ex vivo study of the efficiency of two techniques for the removal of mineral trioxide aggregate used as a root canal filling material. J Endod. 2008;34(10):1239-1242.
60. Chércoles-Ruiz A, Sánchez-Torres A, Gay-Escoda C. Endodontics, endodontic retreatment, and apical surgery versus tooth extraction and implant placement: a systematic review. J Endod. 2017;43(5):679-686.
61. Ng YL, Mann V, Gulabivala K. A prospective study of the factors affecting outcomes of nonsurgical root canal treatment: part 1: periapical health. Int Endod J. 2011;44(7):583-609.
62. Spili P, Parashos P, Messer HH. The impact of instrument fracture on outcome of endodontic treatment. J Endod. 2005;31(12):845-850.

Author contributions

Conceptualization, A.C.B and A.G.G.; methodology, A.C.B. and O.A.D.; software, C.T.D.; validation, A.G.G., O.A.D., L.M.G., C.M.B., M.J.Ț., A.C.B. and C.T.D.; formal analysis, A.G.G., A.C.B., M.J.Ț.; investigation, A.G.G. and A.C.B.; resources, L.M.G.; data curation, X.X.; writ-ing—original draft preparation, A.G.G. and A.C.B.; writing—review and editing, O.A.D. and L.M.G.; visualization, C.T.D.; supervision, O.A.D., L.M.G. and M.J.Ț.; project administration, O.A.D. and M.J.Ț.

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Conflict of interest statement

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Data availability statement

Not applicable.

Ethics statement

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ORIGINAL ARTICLE

DENTAL BLEACHING POSSIBILITIES IN THE DENTAL OFFICE

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Abstract: *(1) Background*: Tooth bleaching is a minimally invasive, precise, practical, conservative, and accessible clinical procedure for patients, involving a low degree of difficulty in performance, resulting in improved tooth color. Different tooth bleaching techniques exist, and their use depends on the type and concentration of the bleaching agent as well as the patient's clinical situation. The study aims to evaluate the aesthetic and clinical efficacy of tooth-bleaching products, analyze their safety, and determine the duration of the bleaching effect. *(2) Methods*: The study was conducted in the Odontotherapy Clinic of the Faculty of Dental Medicine, Craiova, between April 2023 and June 2024. The study analyzed the efficiency and safety of the bleaching products and the duration of the aesthetic effects obtained. After the end of the bleaching treatment, the clinical results were appreciated. The most relevant cases were presented. *(3) Results*: The study includes 15 clinical cases with patients who benefited from tooth bleaching treatment. *(4) Conclusions:* Teeth bleaching with peroxides is an effective method of correcting dental dyschromia, with notable results when performed under the supervision of a specialist under controlled conditions. The area most affected by dental dyschromia is the anterior one, which affects aesthetics and determines patients to want a tooth bleaching treatment.

Keywords: tooth bleaching, aesthetics, dental dyschromia.

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1. Introduction

There is an increasing concern among patients regarding the appearance and especially the color of their teeth. For dentists, managing dental dyschromia involves implementing different treatments or protocols, resulting in improved aesthetic appearance of the teeth [1,2].

Patients desire white teeth due to the emphasis placed on aesthetics. The number of tooth-bleaching treatments performed in dental offices has increased due to a higher patients demand [3-5].

Tooth bleaching is a minimally invasive, safe, reasonably easy-to-perform, relatively low-cost therapeutic method for treating dental dyschromia. The specialized literature describes different tooth bleaching techniques, the choice being influenced by the clinical situation, the type of bleaching agent, the concentration of the bleaching agent, and the vitality of the tooth [6-9].

The clinical tooth bleaching procedure helps improve the color and appearance of the teeth. Whitening can be done either by physically removing stains from the dental structures or through a chemical reaction that causes the degradation of chromogens, ultimately obtaining a lighter shade of color than the initial one [6].

The main bleaching agents used in the clinical tooth bleaching procedure are hydrogen peroxide and carbamide peroxide of different concentrations, their choice being determined by each clinical situation [10-12].

Generally, hydrogen peroxide is used in high concentrations of 35-40%, while carbamide peroxide can also be applied in lower concentrations but also in concentrations of up to 37% [10,12].

The aim of the study was to highlight the clinical stages of performing in-office tooth whitening, to monitor the safety and effectiveness of this procedure, to evaluate the aesthetic results obtained and the indications for subsequent treatments.

2. Materials and method

The present study was conducted during the period April 2023 - June 2024, within the Odontotherapy clinic of the Faculty of Dental Medicine Craiova.

The clinical results were assessed at the end of the bleaching treatment, for the efficacy and safety of the bleaching product.

The study was done as follows: a detailed dental chart was filed for each participant before starting the bleaching treatment. The chart included a history of dietary habits and oral hygiene, oral exam results, and paraclinical examinations. A session of professional hygiene, oral treatments before tooth bleaching, and establishing tooth color was provided for each patient before bleaching. At the end of the bleaching treatment, a complete oral exam was performed to determine the status and color of bleached teeth. Patients will be followed up 6 months and 12 months after the end of the bleaching treatments.

For each follow-up session, the medical history regarding eating habits and oral hygiene, examination of the oral cavity and determination of the dental-periodontal status, paraclinical examinations, and establishing of tooth color were done.

We used the visual method for the color reading with the Vitapan Classic and Vitapan 3D Master color keys. The criteria for including the patient in the study were: (1)

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written consent of the patient; (2) the presence of discoloration of the dental tissues that required chemical treatment or retreatment of tooth bleaching, with the primary objective of preventing and resolving dyschromia.

The criteria for excluding the patient from the study were: (1) periodontal disease; (2) young patient with incompletely formed apex; (3) advanced dental wear.

During the dental bleaching treatments performed on the sample of patients taken into the study, the resources were the clinical chart, the Vitapan Classic and Vitapan 3D Master color keys, the clinical case photography before and after the treatment, the Woodpecker ultrasonic scaler, the contra-angle handpiece, brushes for professional brushing, the abrasive hygiene paste, the dam system to obtain isolation of the operating field, as well as to prevent possible accidents, the liquid dam, sterile rolls, the Flache Zoom dental whitening device from Dentotal Protect, the Philips Zoom whitening lamp (Figure 1), the light-curing lamp, the Opalescence Booster syringe, the Zoom Kit Dental Whitening package (Figure 2).

Figure 1. Philips Zoom whitening lamp.

Figure 2. Zoom Teeth Whitening Kit Package.

The Zoom Kit Tooth Bleaching package contains 2 x Zoom! WhiteSpeed Light-Accelerated Tooth Whitening Gel syringe, 25% concentration, for two patients (packaged separately), 2 x light guide devices, 2 x IsoPrep retractors for soft tissue protection, 4 x face protection bib, 12 x gauze napkin, 4 x cotton roll, 2 x surgical suction cannula, 2 x Liquidam® 2.9 g gingival protection material syringe, with plastic and metal applicators, 2 x whitening gel application brush, 2 x Relief ACP 2.4 g - desensitizing gel, instructions for use.

The studies were carried out according to the approval no. 115/15.06.2022 issued by the Ethics and Scientific Deontology Committee of the University of Medicine and Pharmacy of Craiova.

3. Results

Following the inclusion and exclusion criteria, 15 clinical cases were included. Patients underwent the clinical procedure of tooth bleaching. In all monitored cases, strict

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compliance with the work protocol and the manufacturer's instructions resulted in no adverse effects being recorded. The aesthetic results obtained varied depending on the difference between the initial color and the desired final color, the number of applications of the whitening material, and the need to apply the light curing lamp. Indications for subsequent treatments ranged from applying a fluoride treatment to applying teeth whitening products at home, repeating a teeth whitening session in the office to continuing with indirect aesthetic techniques to achieve the desired result.

We chose three representative cases to present the technical stages followed in different clinical situations and the obtained effects of the tooth bleaching treatment.

Case 1.

Patient V.P., aged 29, presented at the Odontotherapy clinic of the Faculty of Dental Medicine Craiova dissatisfied with the appearance of his teeth in the upper and lower frontal group. The patient complained that he had problems not only with physiognomy but also with speech.

The medical history revealed that the patient consumes large quantities of carbonated drinks such as Coca-Cola and Pepsi and smokes.

During the clinical examination performed by inspection and palpation at the level of teeth 1.1, 1.2, 1.3, and 2.1, 2.2, 2.4, the status of teeth was recorded. These teeth had a yellow-brown color, a characteristic coloration of smoking patients. A diastema is present between teeth 1.1 and 2.1, as well as the rotation of tooth 1.1. Tooth 1.2 is in palatal position; tooth 2.3 is missing; posterior teeth migration and partial space closure.

Unsatisfied with the fact that he has this diastema, but also with the color of the teeth, the patient refuses to contact an orthodontist to align his teeth and accepts physiognomic restoration by indirect veneering. Considering the dark color of the teeth, the decision was to bleach the teeth.

In the first session, professional scaling and brushing were performed to remove stains and discolorations from the tooth surface.

In the second session, an external chemical bleaching was performed.

Hydrogen peroxide is caustic to the soft tissues in the oral cavity, requiring rigorous isolation when applying the gel.

At the gingival level, we applied a liquid dam that we fixed with the help of a photopolymerization lamp. It thus isolates the gums from the irritating action of hydrogen peroxide. In addition, cotton rolls and sterile compresses were used, as well as spacers to protect the patient’s lips and cheeks (Figure 3).

Figure 3. The initial appearance of the teeth.

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The following clinical situation was used as a starting point, with the initial color being visually determined using the Vitapan color chart, namely A4.

After isolating the teeth and placing the gingival barrier, its light-curing was performed for 20 seconds.

The gel was applied after the correct and complete isolation of the teeth to be treated.

According to the manufacturer's instructions, the gel's action time is 20-25 minutes, and after that it was removed with cotton balls and abundant washing.

For a better result, the gel was activated with UV light.

The color change of the involved teeth was surprising after a single session, obtaining the shade A2 (Figure 4).

Figure 4. The appearance of the teeth after the completion of the teeth bleaching treatment.

After the bleaching session, a desensitizing gel was applied with a brush to the entire surface of the front teeth. The gel was removed after two minutes, and the patient rinsed his mouth vigorously.

He did not notice any postoperative sensitivity.

Three weeks after the bleaching session, the indirect veneering treatment could begin.

Case 2.

Patient A.M, 32 years old, male, presented himself at the Odontotherapy clinic of the Faculty of Dental Medicine Craiova, wishing to change the appearance of his teeth. After the medical history, the patient received a suggestion for teeth bleaching treatment. Following the consultation, there were no factors that would contraindicate tooth bleaching (Figure 5).

Figure 5. The initial appearance of the teeth.

The first session included scaling and professional brushing to remove surface stains.

Figure 6. Isolation of the teeth, followed by application of carbamide peroxide gel.

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The patient then presented two days later for the teeth bleaching treatment. External teeth bleaching was performed. First, the initial tooth color was recorded using a shade guide. Then, the teeth were isolated using a liquid dam (Figure 6).

A liquid dam was applied to the gingival level and fixed with the help of a light-curing lamp. It thus isolates the gingiva from the irritating action of carbamide peroxide. In addition, spacers to protect the patient's lips and cheeks were used.

The bleaching was performed in 3 sessions of 20 minutes each, applying a carbamide peroxide-based gel with a lower concentration to avoid post-operative sensitivity.

Finally, the desired color was obtained, and a dental fluoridation treatment was performed (Figure 7).

Figure 7. Appearance of teeth after bleaching treatment.

Case 3.

Patient B.D., 27, male, presented to the Odontotherapy clinic of the Faculty of Dental Medicine Craiova, wishing to change the appearance of his teeth. After taking the medical history, the patient received a suggestion for teeth bleaching treatment. Following the consultation, it was found that there were no factors that would contraindicate teeth bleaching.

In the first session, scaling was performed, followed by professional brushing to remove surface stains.

The patient then presented to the second session, one day later, for the teeth bleaching treatment. The first time, the initial tooth color was recorded using a shade guide, obtaining the color 2M3 (Figure 8).

Figure 8. Initial tooth color 2M3.

The bleaching was performed using a gel with a concentration of 35% hydrogen peroxide for 20 minutes after applying the gingival protection from the whitening kit. Hydrogen peroxide is caustic for the soft tissues in the oral cavity, requiring their rigorous isolation at the time of application of the gel.

A liquid dam was applied to the gingival level, which we fixed with the help of the photopolymerization lamp. It thus isolates the gingiva from the irritating action of the hydrogen peroxide. In addition, cotton rolls, sterile compresses, and spacers were used to protect the patient's lips and cheeks.

The gel was applied after the correct and complete isolation of the teeth, after drying them beforehand.

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The gel's action time was respected according to the manufacturer's instructions, after which it was removed with cotton balls and by abundant washing with water.

The desired chromatic result was achieved, and a dental fluoridation treatment was performed. (**Figure 9, Figure 10**).

Figure 9. Final appearance.

Figure 10. Final appearance.

4. Discussions

Patients who experience tooth discoloration often choose to undergo tooth bleaching procedures. Achieving the desired result in tooth bleaching requires accuracy in establishing the diagnosis and the specific type of dyschromia on the tooth surface. The two main categories of tooth discoloration sources are intrinsic and extrinsic staining [13-15].

Different methods of activating bleaching agents, such as light sources, can be used to accelerate their action, resulting in a decrease in treatment duration. Therefore, different light sources can activate bleaching agents, thus increasing the possibility of free radical release and oxidative capacity [16,17].

However, within the specialized literature, activating bleaching agents with light sources is an intensely debated topic, with supporters and opponents regarding their effectiveness on tooth bleaching [16-18].

Recent studies confirm the improvement of the whitening effect on natural teeth when the bleaching agents are activated by light sources [19-22]. This aspect was observed in the present study, where light activation was used, obtaining excellent results.

Hydrogen peroxide is one of the most widely used bleaching agents, and its concentrations vary depending on the patient's clinical situation. High concentrations of hydrogen peroxide are used to obtain the best results. The tooth bleaching process involves an oxidation reaction, transforming the chromogenic compounds into colorless forms [23-25].

Despite its proven effectiveness, tooth bleaching performed in the office with hydrogen peroxide requires multiple applications of the bleaching agent or even multiple treatment sessions to achieve the desired results. Thus, tooth sensitivity may occur, one of the most common complications of tooth bleaching [19,26-28].

Tooth sensitivity manifests by the appearance of discomfort that the patient complains of immediately or a few days after the tooth bleaching treatment. The

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application of chemical desensitizing agents helps to prevent the occurrence of tooth sensitivity. These chemical agents help obliterate dentinal tubules, remineralize, and reduce excitability through ion deposition [29-31]. Post-bleaching sensitivity did not occur in the present study due to the desensitizing gel used after bleaching.

Laser therapy, an intensely debated topic in the specialized literature, represents another alternative to prevent or treat post-bleaching tooth sensitivity, being [32-35].

For patients with fillings, it was decided to replace dental fillings later after bleaching due to the changes produced by the bleaching substances on their surface [36-37].

5. Conclusions

To apply bleaching treatment, a teeth hygiene treatment must be carried out beforehand, consisting of professional scaling and brushing with abrasive pastes. Chemical bleaching with peroxides leads to good results, mainly when performed with high concentrations in a controlled environment, i.e., in the dental office. Strict compliance with the work protocol allows the desired aesthetic results to be achieved without adverse reactions to the surrounding tissues.

References

1. Kahler B. Present status and future directions - Managing discoloured teeth. Int Endod J. 2022 Oct;55 Suppl 4(Suppl 4):922-950. doi: 10.1111/iej.13711. Epub 2022 Mar 8. PMID: 35188275; PMCID: PMC9790475.
2. Tekce AU, Yazici AR. Clinical comparison of diode laser- and LED-activated tooth bleaching: 9-month follow-up. Lasers Med Sci. 2022 Oct;37(8):3237-3247. doi: 10.1007/s10103-022-03612-1. Epub 2022 Jul 12. PMID: 35829976.
3. Alkahtani R, Stone S, German M, Waterhouse P. A review on dental whitening. J Dent. 2020 Sep;100:103423. doi: 10.1016/j.jdent.2020.103423. Epub 2020 Jun 29. PMID: 32615235.
4. Vochikovski L, Favoreto MW, Rezende M, Terra RMO, Gumy FN, Loguercio AD, Reis A. Use of infrared photobiomodulation with low-level laser therapy for reduction of bleaching-induced tooth sensitivity after in-office bleaching: a double-blind, randomized controlled trial. Lasers Med Sci. 2022 Dec 23;38(1):18. doi: 10.1007/s10103-022-03682-1. PMID: 36562868; PMCID: PMC9782280.
5. Moosavi H, Darvishzadeh F. The Influence of Post Bleaching Treatments in Stain Absorption and Microhardness. Open Dent J. 2016 Mar 25;10:69-78. doi: 10.2174/1874210616021000069. PMID: 27099635; PMCID: PMC4814726.
6. Carey CM. Tooth whitening: what we now know. J Evid Based Dent Pract. 2014 Jun;14 Suppl:70-6. doi: 10.1016/j.jebdp.2014.02.006. Epub 2014 Feb 13. PMID: 24929591; PMCID: PMC4058574.
7. Krishnakumar K, Tandale A, Mehta V, Khade S, Talreja T, Aidasani G, Arya A. Post-Operative Sensitivity and Color Change Due to In-Office Bleaching With the Prior Use of Different Desensitizing Agents: A Systematic Review. Cureus. 2022 Apr 11;14(4):e24028. doi: 10.7759/cureus.24028. PMID: 35547454; PMCID: PMC9090214.

8. Carneiro TS, Favoreto MW, Ferreira MWC, Bernardi LG, Andrade HF, Bandeca MC, Reis A, Ceballos García L, Loguercio AD. In-office dental bleaching in adolescents using 6% hydrogen peroxide with different application tips: randomized clinical trial. J Appl Oral Sci. 2023 Oct 27;31:e20230216. doi: 10.1590/1678-7757-2023-0216. PMID: 37909527; PMCID: PMC10609651.
9. Zhong BJ, Yang S, Hong DW, Cheng YL, Attin T, Yu H. The Efficacy of At-home, In-office, and Combined Bleaching Regimens: A Randomized Controlled Clinical Trial. Oper Dent. 2023 May 1;48(3):E71-E80. doi: 10.2341/22-099-C. PMID: 37079917.
10. Guedes RA, Carlos NR, Turssi CP, França FMG, Vieira-Junior WF, Kantovitz KR, Bronze-Uhle ES, Lisboa-Filho PN, Basting RT. Hybrid light applied with 37% carbamide peroxide bleaching agent with or without titanium dioxide potentializes color change effectiveness. Photodiagnosis Photodyn Ther. 2023 Dec;44:103762. doi: 10.1016/j.pdpdt.2023.103762. Epub 2023 Aug 26. PMID: 37640206.
11. Chemin K, Rezende M, Loguercio AD, Reis A, Kossatz S. Effectiveness of and Dental Sensitivity to At-home Bleaching With 4% and 10% Hydrogen Peroxide: A Randomized, Triple-blind Clinical Trial. Oper Dent. 2018 May/Jun;43(3):232-240. doi: 10.2341/16-260-C. PMID: 29676979.
12. Ittatirut S, Matangkasombut O, Thanyasrisung P. In-office bleaching gel with 35% hydrogen peroxide enhanced biofilm formation of early colonizing streptococci on human enamel. J Dent. 2014 Nov;42(11):1480-6. doi: 10.1016/j.jdent.2014.08.003. Epub 2014 Aug 15. PMID: 25132364.
13. Ahmed HM, Abbott PV. Discolouration potential of endodontic procedures and materials: a review. Int Endod J. 2012 Oct;45(10):883-97. doi: 10.1111/j.1365-2591.2012.02071.x. Epub 2012 May 23. PMID: 22621247.
14. Krastl G, Allgayer N, Lenherr P, Filippi A, Taneja P, Weiger R. Tooth discoloration induced by endodontic materials: a literature review. Dent Traumatol. 2013 Feb;29(1):2-7. doi: 10.1111/j.1600-9657.2012.01141.x. Epub 2012 Apr 19. PMID: 22513082.
15. Plotino G, Buono L, Grande NM, Pameijer CH, Somma F. Nonvital tooth bleaching: a review of the literature and clinical procedures. J Endod. 2008 Apr;34(4):394-407. doi: 10.1016/j.joen.2007.12.020. Epub 2008 Feb 15. PMID: 18358884.
16. Costa JLSG, Besegato JF, Kuga MC. Bleaching and microstructural effects of low concentration hydrogen peroxide photoactivated with LED/laser system on bovine enamel. Photodiagnosis Photodyn Ther. 2021 Sep;35:102352. doi: 10.1016/j.pdpdt.2021.102352. Epub 2021 May 26. PMID: 34051345.
17. Domínguez A, García JA, Costela A, Gómez C. Influence of the light source and bleaching gel on the efficacy of the tooth whitening process. Photomed Laser Surg. 2011 Jan;29(1):53-9. doi: 10.1089/pho.2009.2751. Epub 2010 Oct 22. PMID: 20969438.
18. De Moor RJ, Verheyen J, Diachuk A, Verheyen P, Meire MA, De Coster PJ, Keulemans F, De Bruyne M, Walsh LJ. Insight in the chemistry of laser-activated dental bleaching. ScientificWorldJournal. 2015;2015:650492. doi: 10.1155/2015/650492. Epub 2015 Mar 22. PMID: 25874251; PMCID: PMC4385672.
19. Kiryk, Jan, Sylwia Kiryk, Julia Kensy, Witold Świenc, Barbara Palka, Małgorzata Zimoląg-Dydak, Wojciech Dobrzyński, Jacek Matys, Maciej Dobrzyński. Effectiveness of Laser-Assisted Teeth

Bleaching: A Systematic Review. Appl. Sci. 2024, 14, 20, 9219. https://doi.org/10.3390/app14209219.

20. Shokouhinejad N, Khoshkhounejad M, Hamidzadeh F. Evaluation of the Effectiveness of Laser-Assisted Bleaching of the Teeth Discolored due to Regenerative Endodontic Treatment. Int J Dent. 2022 Jul 6;2022:3589609. doi: 10.1155/2022/3589609. PMID: 35847349; PMCID: PMC9279097
21. Naik PL, Valli K. Comparative study of effects of home bleach and laser bleach using digital spectrophotometer: An in vitro study. J Conserv Dent. 2022 Mar-Apr;25(2):161-165. doi: 10.4103/jcd.jcd_568_21. Epub 2022 May 4. PMID: 35720824; PMCID: PMC9205359.
22. Saluja I, Shetty N, Shenoy R, Pangal SN. Evaluation of the efficacy of diode laser in bleaching of the tooth at different time intervals using spectrophotometer: An in vitro study. J Conserv Dent. 2022 Mar-Apr;25(2):166-172. doi: 10.4103/jcd.jcd_621_21. Epub 2022 May 4. PMID: 35720817; PMCID: PMC9205357.
23. Mawlood AA, Hamasaeed NH. The impact of the diode laser 940 nm photoactivated bleaching on color change of different composite resin restorations. J Adv Pharm Technol Res. 2023 Apr-Jun;14(2):155-160. doi: 10.4103/japtr.japtr_45_23. Epub 2023 Apr 13. PMID: 37255881; PMCID: PMC10226697.
24. Al-Maliky MA. Clinical Investigation of 940 nm Diode Laser Power Bleaching: An In Vivo Study. J Lasers Med Sci. 2019 Winter;10(1):33-36. doi: 10.15171/jlms.2019.05. Epub 2018 Dec 15. PMID: 31360366; PMCID: PMC6499584.
25. Bortolatto JF, Pretel H, Floros MC, Luizzi AC, Dantas AA, Fernandez E, Moncada G, de Oliveira OB Jr. Low Concentration H(2)O(2)/TiO_N in Office Bleaching: A Randomized Clinical Trial. J Dent Res. 2014 Jul;93(7 Suppl):66S-71S. doi: 10.1177/0022034514537466. Epub 2014 May 27. PMID: 24868014; PMCID: PMC4293723.
26. de Geus JL, Wambier LM, Kossatz S, Loguercio AD, Reis A. At-home vs In-office Bleaching: A Systematic Review and Meta-analysis. Oper Dent. 2016 Jul-Aug;41(4):341-56. doi: 10.2341/15-287-LIT. Epub 2016 Apr 5. PMID: 27045285.
27. Mounika A, Mandava J, Roopesh B, Karri G. Clinical evaluation of color change and tooth sensitivity with in-office and home bleaching treatments. Indian J Dent Res. 2018 Jul-Aug;29(4):423-427. doi: 10.4103/ijdr.IJDR_688_16. PMID: 30127190.
28. Cabral AEA, Lourenço MAG, de Medeiros Santos BS, Carvalho MG, Pazinatto RB, Leite FPP, de Melo LA. Effectiveness of desensitizing toothpastes in reducing tooth sensitivity after tooth bleaching: a systematic review. Clin Oral Investig. 2024 Jul 30;28(8):457. doi: 10.1007/s00784-024-05857-2. PMID: 39078468.
29. Papazisi N, Dionysopoulos D, Naka O, Strakas D, Davidopoulou S, Tolidis K. Efficiency of Various Tubular Occlusion Agents in Human Dentin after In-Office Tooth Bleaching. J Funct Biomater. 2023 Aug 17;14(8):430. doi: 10.3390/jfb14080430. PMID: 37623674; PMCID: PMC10455242.
30. Clark D, Levin L. Non-surgical management of tooth hypersensitivity. Int Dent J. 2016 Oct;66(5):249-56. doi: 10.1111/idj.12247. Epub 2016 Jun 15. PMID: 27301300; PMCID: PMC9376650.
31. Basting RT, Amaral FL, França FM, Flório FM. Clinical comparative study of the effectiveness of and tooth sensitivity to 10%

and 20% carbamide peroxide home-use and 35% and 38% hydrogen peroxide in-office bleaching materials containing desensitizing agents. Oper Dent. 2012 Sep-Oct;37(5):464-73. doi: 10.2341/11-337-C. Epub 2012 May 18. PMID: 22616927.

32. Pompeu DDS, de Paula BLF, Barros APO, Nunes SC, Carneiro AMP, Araújo JLN, Silva CM. Combination of strontium chloride and photobiomodulation in the control of tooth sensitivity post-bleaching: A split-mouth randomized clinical trial. PLoS One. 2021 Apr 28;16(4):e0250501. doi: 10.1371/journal.pone.0250501. PMID: 33909659; PMCID: PMC8081218.
33. de Paula B, Alencar C, Ortiz M, Couto R, Araújo J, Silva C. Effect of photobiomodulation with low-level laser therapy combined with potassium nitrate on controlling post-bleaching tooth sensitivity: clinical, randomized, controlled, double-blind, and split-mouth study. Clin Oral Investig. 2019 Jun;23(6):2723-2732. doi: 10.1007/s00784-018-2715-4. Epub 2018 Oct 25. PMID: 30361793.
34. Giannakopoulou Paraskevi, Chariklia Neophytou, Panagiotis Karakostas, Konstantinos Papadimitriou, Dimitrios Dionysopoulos, Kosmas Tolidis, Sotiria Davidopoulou. Low-Level Laser Therapy for Tooth Sensitivity after Tooth Bleaching: A Systematic Review. Appl. Sci. 2024,14,17, 8068. https://doi.org/10.3390/app14178068
35. Liu XX, Tenenbaum HC, Wilder RS, Quock R, Hewlett ER, Ren YF. Pathogenesis, diagnosis and management of dentin hypersensitivity: an evidence-based overview for dental practitioners. BMC Oral Health. 2020 Aug 6;20(1):220. doi: 10.1186/s12903-020-01199-z. PMID: 32762733; PMCID: PMC7409672.
36. Popescu AD, Țuculină MJ, Gheorghiță LM, Osman A, Nicolicescu C, Bugălă SA, Ionescu M, Abdul-Razzak J, Diaconu OA, Dimitriu B. An In Vitro Study regarding the Wear of Composite Materials Following the Use of Dental Bleaching Protocols. J Funct Biomater. 2023 Oct 21;14(10):532. doi: 10.3390/jfb14100532. PMID: 37888197; PMCID: PMC10607896.
37. Popescu AD, Tuculina MJ, Diaconu OA, Gheorghiță LM, Nicolicescu C, Cumpătă CN, Petcu C, Abdul-Razzak J, Rîcă AM, Voinea-Georgescu R. Effects of Dental Bleaching Agents on the Surface Roughness of Dental Restoration Materials. Medicina (Kaunas). 2023 Jun 1;59(6):1067. doi: 10.3390/medicina59061067. PMID: 37374271; PMCID: PMC10303374.

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Conflict of interest statement

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REVIEW

CUSTOMIZED (CAD/CAM) POSTS AND CORES – CONSIDERATIONS REGARDING FABRICATION

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Abstract: This systematic review presents an overall presentation of existing research materials on post-core restorations in terms of content, materials, fabrications, and performance. The research methodology for this work will follow the strategy by integrating a refined methodical search approach, setting the inclusion and exclusion criteria, and specifying certain requirements based on which the relevant literature will be selected for the synthesis of results. Three independent reviewers conducted database searches to obtain literature from the years 2013 to 2024, which was later summarized. A total of 185 titles were obtained through electronic database searches. Regarding, the post and core restoration, advancements have been made in both conventional and CAD/CAM technologies. To date, several methodologies have been published regarding the CAD/CAM post-core restoration of endodontically treated teeth using direct and indirect methods.

Keywords: CAD/CAM, post and core, restoration, endodontically treated teeth, Zirconia.

1. Introduction

Zirconia, composite resins, and hybrid ceramics are frequently cited as the materials typically documented in this context [1]. While the existing research on CAD/CAM posts and cores is scarce, additional investigations are necessary to assess the extended durability and effectiveness of this treatment approach [2].

They are usually more flexible in relation to the prepared post space and do not pose a problem in any other configuration. This is probably the right solution for elliptical or flared canal modifications when prefabricated posts cannot handle the situation optimally. The increased flexibility of the custom-cast post and core enhanced the resistance to torsional stress [3].

Thus, even in compromised teeth where teeth have lost structure during tooth preparation, and access cavity preparation, custom posts also provide resistance to rotation to multi-rooted teeth. The materials for post and core must exhibit excellent crown retention, be biocompatible and non-toxic, possess strong tensile properties, and demonstrate resistance to fatigue when subjected to occlusal and shear forces [4]. The dental post should evenly distribute pressure across the surrounding root surface and extend downward to at least the height of the crown or two-thirds of the root length. This design facilitates efficient stress dissipation and improves resistance to biting forces [5]. A major added achievement is the resemblance in colour between the post and core with natural dentin [6]. Tar-Gold-Platered CAD/CAM manufactured posts and cores exist today [7].

Most teeth are fitted with oval canals so that the post and core are customized, and canal obstruction is made easy in cases of retreatment. Therefore, the post and core act as one entity, thereby reducing the chance of core separation. In restorative procedures for teeth that are angled forward, even when using crown-angled techniques, it is possible to adjust the orientation of cast post and cores to align with the crown's shape, which is considered appropriate [8,9]. Research by Balkenhol et al. demonstrated a positive long-term outlook for teeth with custom cast post and cores, showing a 7.3-year survival rate [10]. Additional studies conducted by Dietschi et al. corroborated these findings, confirming the high resistance to fracture in teeth treated using custom-cast posts and cores [11].

Posts and cores can be constructed from either metallic or non-metallic substances [12]. The metallic posts and cores offer ease of fabrication and are considered cost-effective solutions [13]. In general, non-noble metals have the lowest relative costs [14]. The majority of the outcomes from the study meetings showed that most of the materials used did not provide fully accepted results as required for dental applications.

Because patient demand is conservative, there is a greater awareness of the benefits of adhesive dentistry; the standard cast post and core are among many options [15]. The fabrication process may involve direct techniques using resins or indirect methods that utilize elastomeric impressions of the prepared canal [8].

The adoption of castable glass ceramics and glass-infiltrated ceramics has grown in recent years. Zirconia posts were first applied

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to dental procedures in 1995, when substantial structures from the coronal plane began to serve as an alternative to traditional cast metal posts and cores [16].

2. Materials and method

"CAD/CAM", "post and core", "Zirconia" were searched over the last 9 years from 2013 to 2024. A total of 324 results were obtained, with 145 and 179 results retrieved from PubMed and Scopus, respectively. Initial de-duplication led to the removal of 98 records. Six articles had no English versions. Subsequently, the remaining 220 articles were screened through titles and abstracts to remove studies unrelated to dentistry.185 studies were further assessed to establish their eligibility for inclusion in the review.

Articles were purposely selected in accord with the research objective of existing research materials on post-core restorations in terms of content, materials, fabrications, and performance. The articles inclusion criteria were: CAD/CAM post and core restorations, direct restoration using CAD/CAM, CAD/CAM manufacturing, or digital dentistry techniques for post and core procedures and written in English or full text English version was available.

Articles were excluded if they used other qualitative research methods or the main subject of the study did not wholly concern dentistry.

An initial total of 185 articles was identified through the electronic database searching, with the rest sourced from bibliography hand searches. After duplicate elimination, 92 articles remained for screening and eventual application of the inclusion criteria. Generally, a total of 26 articles met the required criteria and had relevance to the practice of dentistry. All full articles were studied. Meta-analysis was not conducted as part of this narrative review.

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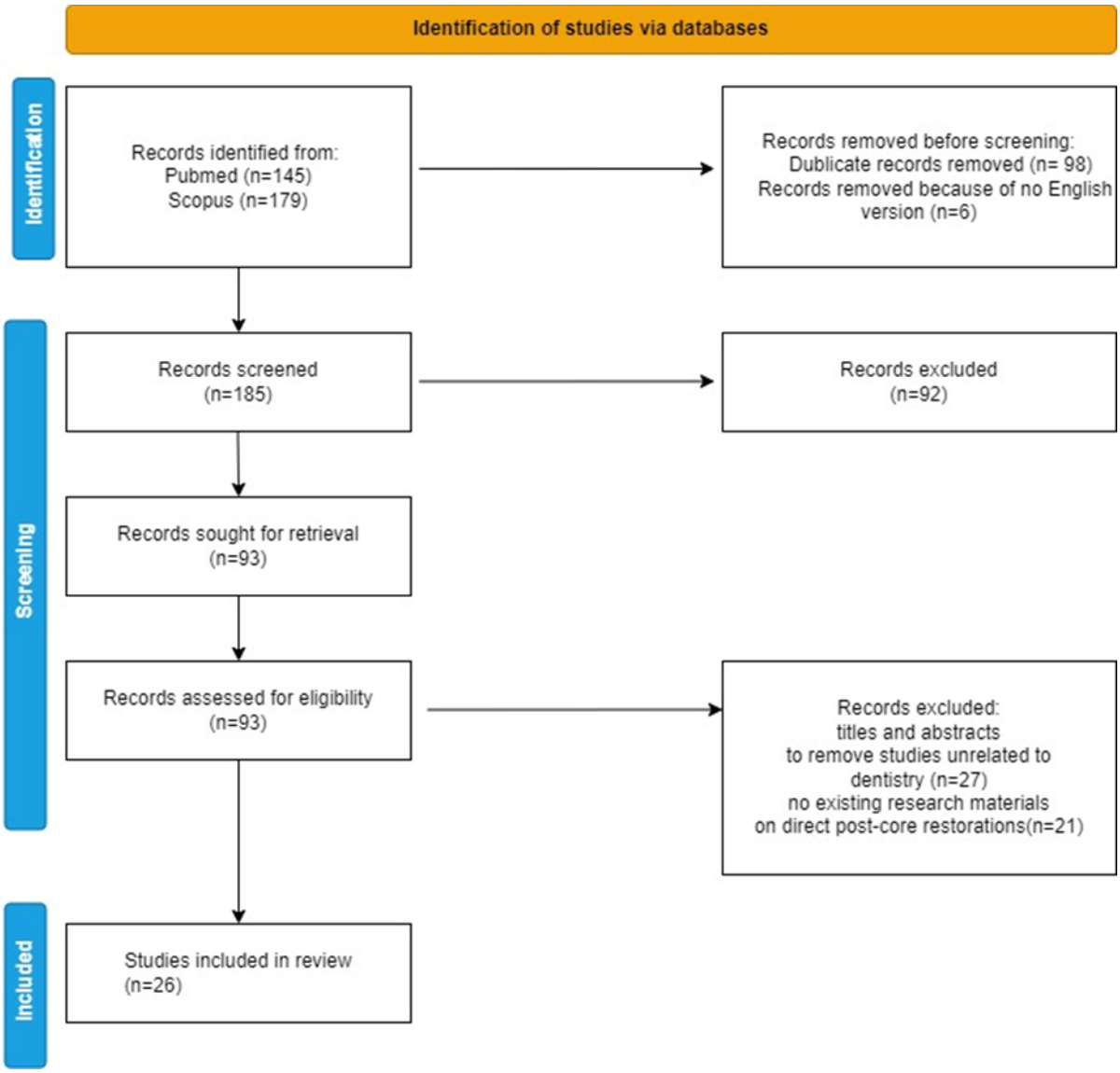

Figure 1. Identification of studies.

3. Results

This investigation aimed to examine the existing literature on post and core restorations, focusing on their composition, manufacturing methods, and effectiveness in clinical settings. After applying the exclusion criteria we got the results included in Table 1.

Table 1. Studies included in this review.

No	Authors	Year	Article type	Technology
1	Li M, Ma B, Zhou Z, Liu W	2024	Research article	CAD/CAM nanoceramic resin restorations
2	Fathey IT, Azer AS, Abdelraheem IM	2024	Research article	CAD-CAM post and core restorations

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3	Terry Douglas, Swift Edward	2010	Clinical trial	Prefabricated Metal Posts/ Prefabricated Nonmetallic Posts(zirconia)
4	Morgano SM, Milot P	1993	Clinical trial	Cast metal posts and cores
5	Dimitrova M, Vlahova A, Kazakova R.	2024	A narrative review	CAD/CAM-based construction of post and cores
6	Marinescu AG, Abuabboud O, Zimbru ȘD, Cîrligeriu LE, Pițˌ BA, Borcean IA, Paven M, Nica LM, Stoia DI	2023	Research article	Fiberglass posts
7	Baba NZ, Golden G, Goodacre CJ	2009	Review	Nonmetallic prefabricated dowels
8	Leven R, Schmidt A, Binder R, Kampschulte M, Vogler J, Wöstmann B, Schlenz MA.	2022	Clinical trial	CAD/CAM Posts and Cores in a Fully Digital Workflow
9	Al-Qarni FD. Customized Post and Cores Fabricated with CAD/CAM Technology: A Literature Review	2022	Review	Customized Post and Cores Fabricated with CAD/CAM Technology
10	Balkenhol M, Wöstmann B, Rein C, et al.	2007	Clinical trial	Custom-fabricated, cast post and cores using a standardised technique
11	Dietschi D, Duc O, Krejci I, et al	2007	Review	Post and core materials
12	Elsubeihi, Emad & Aljafarawi, Tareq & Elsubeihi, Heba	2020	Review	Prefabricated fiber-reinforced posts
13	Lee, Ju-Hyoung & Sohn, Dong-Seok & Lee, Cheong-Hee	2014	Short communication	Fabricating a fiber-reinforced post and zirconia core with CAD/CAM
14	Perlea, Paula & Stefanescu, Cosmin & Al-Aloul, Omar-Andrei & Ionita, Cezar & Alexandru, Petre	2023	Short communication	Hybrid posts and cores
15	Kongkiatkamon, S.; Peampring, C	2022	Clinical trial	Translucent Zirconia Crowns
16	Awad MA, Marghalani TY	2007	Research article	Custom-made ceramic post and core using CAD-CAM technology
17	Bibi, Asma & Azam, Saima & Waseem, Rida	2024	Case report	Custom Made Cast Post and Core
18	MS, Nivedhitha	2020	Research article	Fiber reinforced composite
19	Mehra, Varun & Khera, Amit & Raghav, Pradeep & Yadav, Mohit.	2020	Case report	Custom-made ceramic post and core using CAD-CAM technology
20	Tortopidis D, Lyons MF, Baxendale RH, Gilmour WH	1998	Case report	CAD/CAM technologies with zirconia ceramics
21	Streacker AB, Geissberger M.	2007	Full length article	ceramic post and core
22	Ansarifard E, Farzin M, Zohour Parlack A, Taghva M, Zare R.	2022	Original article	Ni-Cr, NPG and Co-Cr alloys

23	Ying, S., Chen, S., Wang, S. et al.	2022	Research article	CAD/CAM zirconium dioxide post-cores
24	Chazine, Michelle & Casucci, Alessio & Mazzoni, Annalisa & Grandini, Simone & Goracci, Cecilia & Breschi, Lorenzo & Ferrari, Marco.	2012	Research article	Zirconia
25	Al Yahya RS, Al Attas MH, Javed MQ, Khan KI, Atique S, Abulhamael AM, Bahammam HA	2023	Research article	CAD-CAM technology
26	Ali Bagheri Behboud, Md Kawsar Ahmed, Arda Kurucu, Göksenin Kurt Çömlekçi, Mustafa Ordu	2023	Review	Zirconia Nanoparticles

A total of 26 articles were included in this narrative review. They have mainly been categorized fundamentally based on different fabrication methodologies, clinical evaluations, and quality of conventional post and core restorations and CAD/CAM post and core restorations, their applications in different aspects of dentistry, focusing largely on the implications of the main results in the study.

The current investigation was conducted to implement CAD/CAM technology in custom post and core fabrication to address clinical requirements with optimal efficiency. Multiple studies have evaluated CAD/CAM-fabricated posts and cores in comparison to both conventional and prefabricated posts.

Teeth treated with root canal procedures and restored using custom-made zirconia posts exhibited notably higher resistance to fracture compared to those with cast metal posts and cores or glass fibre posts combined with composite resin cores[17]. However, the high elasticity modulus characteristic of zirconia results in increased stress on the root dentin, thereby elevating the risk of root fracture [18]. Furthermore, it is difficult to bond to acid-resistant zirconia, and retrieving it in case of failure to remove it from the root canals would be very challenging for crowns, bridges, removable partial dentures, and complete dentures. There are some of the advantages of this approach: greater accuracy and homogeneity in the production methodology, a more efficient and expeditious approach to creating restorations on a larger scale, and an effective means of quality assurance [19].

Tortopidis et al., used CAD/CAM technologies with zirconia ceramics on restorations. They found that the additive manufacturing process produces dental restorations with much-improved mechanical properties compared to the traditional subtractive method[20].

In 2007, Awad and Marghalani pioneered the application of CAD/CAM technology for post and core fabrication, with Strecker and Geissberger following suit shortly thereafter[21]. The subsequent years have witnessed the implementation of diverse techniques and materials in in vitro studies and case reports, which are thoroughly examined in the ensuing sections.

Recent research has shown that the wear behaviour of CAD/CAM composite resin

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posts and cores is lower than that of conventionally fabricated devices. Posts and copings made by CAD/CAM technology exhibited superior fit in the post-space and necessitated reduced fabrication time, although cast posts and copings demonstrated marginally superior fit. A comparable in vitro study revealed that cast Co-Cr alloy exhibited superior accuracy of apical gap compared to machined Co-Cr alloy [22].

CEREC intraoral camera post lengths up to 9 mm have been reported in several other studies. Therefore, in previous studies, 8 mm was adopted as the length of the post-space preparation before scanning. If the post-space exceeds 10 mm, an indirect procedure is recommended to create CAD/CAM posts and cores. For CAD/CAM posts and corenot achieved by post-retention, cement thickness was measured by direct scanning of the post-space, polyether impression scanning, or plaster model scanning[23]. The post retentions of directly scanned posts and cores were found to be better than those of indirectly scanned posts and cores. The cement thickness and nano leakage were similar between the two groups[24].

The majority of studies reported in the literature have employed an indirect approach to CAD/CAM post and core fabrication. Direct scanning of the root canal region is expedient and immediate; however, indirect approaches may be recommended when rehabilitating teeth with elongated or diminutive root canal spaces [25].

An additional limitation is the challenge in differentiating between materials, as the majority of the published literature consists of case reports, with milled zirconia and glass-fibre-reinforced composites being the most frequently reported materials. Consequently, this study can only provide a basis for further research in which an exhaustive study on the interrelations between different materials and their mechanical characteristics is defined.

Post, retention, and cement thicknesses were assessed indirectly by scanning with post spaces, either polyether impression scanning or plaster model scanning. Post-retention was the highest in directly scanned posts and cores, where the two groups were generally comparable in terms of cement thickness and nano leakage.

CAD CAM technology offers the possibility of creating a hybrid post in the dental office that contains a zirconia core and a fiber-reinforced resin part that can be fitted in the patient mouth on the same day [26].

While its application has been recorded for several other materials, there are few reports for the the clinical application of a CAD/CAM-produced Co-Cr alloy. This inherent aesthetic limitation which is common to metal alloys is a special shortcoming related to most of the time numerous other alternatives superior in aesthetic qualities. However, a 2024 study shows that for metal post and core, no statistically significant difference was identified between digital and conventional impressions, while for zirconia, a significantly higher acceptance rate is evident in conventional impressions, compared to those produced by digital impressions.[27]

A limitation of the present study is in drawing material distinctions, which could be justified by most available literature taking the form of clinical anecdotes, where zirconia and glass-fibre-reinforced composites appear

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to be the most popular among the materials. Thus, this study serves only as a stepping stone for future investigations, which may involve a more detailed study of various materials[28].

4. Conclusions

Such increased availability of CAD/CAM fabricated posts and cores may warrant consideration of this technique as an alternative approach to traditional methods. The fracture resistance, bond strength, adaptability, and aesthetic excellence of post and core restorations are considered impressive features. Nevertheless, limited in vivo research has been conducted to corroborate this evidence. Therefore, it is crucial to perform extended studies to validate the results obtained from these brief clinical trials.

References

1. Li M, Ma B, Zhou Z, Liu W. Influence of impression method and shoulder design on the marginal adaptation of CAD/CAM nanoceramic resin onlay restorations. Heliyon. 2024 Aug 8;10(16):e35915. doi: 10.1016/j.heliyon.2024.e35915.
2. Fathey IT, Azer AS, Abdelraheem IM. Fracture resistance and failure mode of three aesthetic CAD-CAM post and core restorations. BMC Oral Health. 2024 May 3;24(1):523. doi: 10.1186/s12903-024-04273-y. PMID: 38702708.
3. Terry, Douglas & Swift, Edward. (2010). Post-and-cores: Past to present. Dentistry today. 29. 132, 134-5.
4. Morgano SM, Milot P. Clinical success of cast metal posts and cores. J Prosthet Dent. 1993; 70(1): 11-16. doi:10.1016/0022-3913(93)90030-R.
5. Dimitrova M, Vlahova A, Kazakova R. Assessment of CAD/CAM Fabrication Technologies for Post and Core Restorations-A Narrative Review. Medicina (Kaunas). 2024 Apr 30;60(5):748. doi: 10.3390/medicina60050748.
6. Marinescu AG, Abuabboud O, Zimbru ȘD, Cîrligeriu LE, PițBA, Borcean IA, Paven M, Nica LM, Stoia DI. Influence of the Fiber Post Length on the Fracture Strength of Endodontically Treated Teeth. Medicina (Kaunas). 2023 Oct 9;59(10):1797. doi: 10.3390/medicina59101797.
7. Baba NZ, Golden G, Goodacre CJ. Nonmetallic prefabricated dowels: a review of compositions, properties, laboratory, and clinical test results. J Prosthodont. 2009 Aug;18(6):527-36. doi: 10.1111/j.1532-849X.2009.00464.x
8. Leven R, Schmidt A, Binder R, Kampschulte M, Vogler J, Wöstmann B, Schlenz MA. Accuracy of Digital Impression Taking with Intraoral Scanners and Fabrication of CAD/CAM Posts and Cores in a Fully Digital Workflow. Materials (Basel). 2022 Jun 13;15(12):4199. doi: 10.3390/ma15124199. PMID: 35744261; PMCID: PMC9228234.
9. Al-Qarni FD. Customized Post and Cores Fabricated with CAD/CAM Technology: A Literature Review. Int J Gen Med. 2022 May 6;15:4771-4779. doi: 10.2147/IJGM.S365296.
10. Balkenhol M, Wöstmann B, Rein C, et al. Survival time of cast post and cores: a 10-year retrospective study. J Dent. 2007; 35(1): 50-58.
11. Dietschi D, Duc O, Krejci I, et al. Biomechanical considerations for the

restoration of endodontically treated teeth: a systematic review of the literature–part 1. Composition and micro- and macrostructure alterations. Quintessence Int. 2007; 38(9): 733-43.

12. Elsubeihi, Emad & Aljafarawi, Tareq & Elsubeihi, Heba. (2020). State of the Art Contemporary Prefabricated Fiber-Reinforced Posts. The Open Dentistry Journal. 14. 313-323.
13. Lee, Ju-Hyoung & Sohn, Dong-Seok & Lee, Cheong-Hee. (2014). Fabricating a fiber-reinforced post and zirconia core with CAD/CAM technology. The Journal of prosthetic dentistry. 112.
14. Perlea, Paula & Stefanescu, Cosmin & Al-Aloul, Omar-Andrei & Ionita, Cezar & Alexandru, Petre. (2023). Digital Workflow for Producing Hybrid Posts and Cores. Healthcare. 11. 727. 10.3390/healthcare11050727.
15. Kongkiatkamon, S.; Peampring, C. Comparison of Regular and Speed Sintering on Low-Temperature Degradation and FatigueResistance of Translucent Zirconia Crowns for Implants: An In Vitro Study. J. Funct. Biomater.2022,13, 281.
16. Awad MA, Marghalani TY. Fabrication of a custom-made ceramic post and core using CAD-CAM technology. J Prosthet Dent. 2007; 98(2): 161-162. doi:10.1016/S0022-3913(07)60050-X.
17. Bibi, Asma & Azam, Saima & Waseem, Rida. (2024). Restoration of Bilateral Premolars Using Custom Made Cast Post and Core: A Case Report. Journal of Islamabad Medical & Dental College. 13. 10.35787/jimdc.v13i1.1119.
18. MS, Nivedhitha. (2020). Evaluation of Different Post Endodontic Restorations used in Endodontically Treated Maxillary and Mandibular Anteriors - An Institution Based Retrospective Study. International Journal of Dentistry and Oral Science. 31-37. 10.19070/2377-8075-SI02-010006.
19. Mehra, Varun & Khera, Amit & Raghav, Pradeep & Yadav, Mohit. (2020). Ortho-prostho interdisciplinary approach to improve esthetics in anterior region: A case report.
20. Tortopidis D, Lyons MF, Baxendale RH, Gilmour WH. The variability of bite force measurement between sessions, in different positions within the dental arch. J Oral Rehabil. 1998 Sep;25(9):681-6. doi: 10.1046/j.1365-2842.1998.00293.x. PMID: 9758398.
21. Streacker AB, Geissberger M. The milled ceramic post and core: a functional and esthetic alternative. J Prosthet Dent. 2007; 98(6): 486-487. doi:10.1016/S0022-3913(07)60151-6.
22. Ansarifard E, Farzin M, Zohour Parlack A, Taghva M, Zare R. Comparing Castability of Nickel-Chromium, Cobalt-Chromium, and Non-Precious Gold Color Alloys, Using two Different Casting Techniques. J Dent (Shiraz). 2022 Mar;23(1):7-12. doi: 10.30476/DENTJODS.2021.87573.1275.
23. Ying, S., Chen, S., Wang, S. et al. Outcome of teeth restored with CAD/CAM zirconium dioxide post-cores: a retrospective study with a follow-up period of 3–6 years. BMC Oral Health 22, 236 (2022). https://doi.org/10.1186/s12903-022-02273-4.
24. Chazine, Michelle & Casucci, Alessio & Mazzoni, Annalisa & Grandini, Simone & Goracci, Cecilia & Breschi, Lorenzo & Ferrari, Marco. (2012). Interfacial nanoleakage and internal cement thickness of three aesthetic crown systems. Dental materials : official publication of the Academy of Dental Materials. 28. 1105-11. 10.1016/j.dental.2012.07.005.
25. Al Yahya RS, Al Attas MH, Javed MQ, Khan KI, Atique S, Abulhamael AM,

Bahammam HA. Root Canal Configuration and Its Relationship with Endodontic Technical Errors and Periapical Status in Premolar Teeth of a Saudi Sub-Population: A Cross-Sectional Observational CBCT Study. Int J Environ Res Public Health. 2023 Jan 9;20(2):1142. doi: 10.3390/ijerph20021142.

26. Perlea P, Stefanescu C, Al-Aloul OA, Ionita C, Petre AE. Digital Workflow for Producing Hybrid Posts and Cores. Healthcare (Basel). 2023 Mar 2;11(5):727. doi: 10.3390/healthcare11050727. PMID: 36900732; PMCID: PMC10001014.
27. Perlea P, Stefanescu C, Petre AE. Clinical Acceptance of Digitally Produced Zirconia and Metal Post and Cores, Based on the Impression Method. Clin Pract. 2024 Nov 20;14(6):2533-2541. doi: 10.3390/clinpract14060199.
28. Ali Bagheri Behboud, Md Kawsar Ahmed, Arda Kurucu, Göksenin Kurt Çömlekçi, Mustafa Ordu, Zirconia nanoparticle coating for high-strength and alkali-resistant glass fibres, Journal of Non-Crystalline Solids, Volume 619,2023,122571,ISSN 0022-3093, https://doi.org/10.1016/j.jnoncrysol.2023.122571.

Author contributions

S.B and A.R contributed to the study design, the data acquisition, analysis, and interpretation, and wrote the manuscript draft. M.T contributed to the study design, and the interpretation of the results, and revised the manuscript. D.A and A.B contributed to the study design, revised the manuscript, and supervised the work. All authors have read and approved the final manuscript.

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Data availability statement

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ORIGINAL ARTICLE

DIGITAL IMPRESSION TECHNOLOGIES – INTRAORAL SCANNING USED IN RESTORATIVE DENTISTRY

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Abstract: In recent years, there have been many technological advances in intraoral scanners. These developments have improved the efficiency and accuracy of intraoral scanning in CAD/CAM. *(1) Background*: The study aimed to compare results obtained in dental impression technology with IOSs to impressions taken with conventional impression materials. *(2) Methods*: the stages of two types of clinical oral rehabilitation (in dentate and edentulous patients) were compared. In each clinical situation, both impressions were taken using the classic impression method and digital impressions by intraoral scanning, one involving fixed prosthetics and the other removable prosthetics. *(3) Results*: During and after taking intraoral impressions using both the classic and digital methods via intraoral scanning, the digital impression produced a more positive perception than the classic impression. The time needed to perform an impression was statistically significantly shorter for digital one in dentate patients but longer in edentulous patients. *(4) Conclusions*: Intraoral digital impression techniques offer significant advantages over conventional methods that use impression material to increase patient comfort and improve communication between patients, dental technicians, and clinicians. These advantages are essential for dentate patients.

Keywords: intraoral scanning, accuracy, precision.

1. Introduction

Although Francoise Duret had been developing a new technology for intraoral scanning since the beginning of the 1970s, the first to introduce digital impression technology in the dental practice were Mörmann and Brandestini more than 10 years later [1].

While in the first decades, the CEREC system was the only commercially available intraoral scanner, in the last decade, many manufacturers have started to provide their solutions. Currently, more scanning technologies are available for digital intraoral impression systems [2].

CAD/CAM systems emerged simultaneous with digital impressions using intraoral scanners within a fully digital workflow. Digital impressions are obtained via intraoral scanners, which collect the information needed by projecting light [3]. The advantages of digital impressions are related to a lower risk of distortion of the physical impression material used in conventional techniques and increased patient comfort [4-6].

Regardless of the technology, intraoral digital scanners assemble 3D models by photographing and stitching together multiple photos taken from the oral cavity. This stitching process, which consists of the alignment of these numerous images, although critical, can be affected by a series of errors that may arise and compromise the overall accuracy of the digital impression [7-9]. An intraoral scanner's most critical mathematical characteristics are accuracy [10,11] and resolution [12].

When discussing digital impression accuracy, the terms "accuracy", "trueness", and "precision" should be distinguished from each other. According to the definition by the International Organization for Standardization (ISO 5725-1) in 1994, "accuracy" indicates the combination of "correctness" and "precision", where "correctness" is defined as "the closeness of agreement between the arithmetic mean of a large number of test results and the true or accepted reference value". Meanwhile, "precision" has been defined as "the closeness of agreement between different test results" [13].

In recent years, hardware and software innovations have driven many technological advances in intraoral scanners. These developments have improved the efficiency and accuracy of intraoral scanning in computer-aided design and computer-aided manufacturing (CAD-CAM). One of the most significant advances is the expansion of their capabilities, from simple intraoral scanning to diagnosis, treatment planning, and patient monitoring [14].

The objective of this study was to assess, comparatively, the advantages and improvements of the dental impression technology taken with IOSs and conventional impressions, as well as the limitations related to the use of the digital impression technique through intraoral scanning and classical impression technique.

2. Materials and method

The study occurred between October 2022 and January 2024 in the Oral Rehabilitation Clinic of the Faculty of Dentistry of Craiova. The study selected participants from the patients presented for oral rehabilitation. All patients gave

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informed consent for treatment and participation in the study. The Ethics Committee of the University of Medicine and Pharmacy of Craiova approved study 197/20.12.2021.

In the impression stage of the oral rehabilitation process, two types of impressions were obtained: the conventional impression and the optical impression. For the traditional impression, we used silicone and standard trays.

Medit i700 intraoral scanner with the Medit Link v.3.2.3 software (Medit, Seoul, Republic of South Korea) was used for the optical impressions. The intraoral scanner was calibrated according to the manufacturer's guidelines.

The stages of oral rehabilitation cases were performed according to the treatment plan, implying fixed or removable prosthodontics.

Working flow for dentate patients

The treatment plan was established and implemented following the patient's history and examination.

Figure 1. Tooth preparations resulting after grinding in a case of oral rehabilitation through porcelain veneers.

After preparing the teeth by grinding (Figure 1), digital and classic impression steps followed.

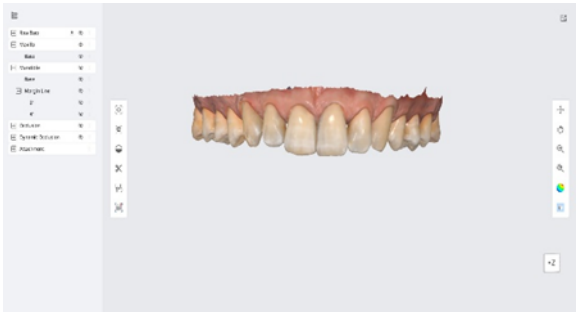

Figure 2. Digital impression of the upper arch.

The digital impression was taken by intraoral scanning with a Medit I700 scanner, consisting in maxilla jaw (Figure 2), mandible jaw (Figure 3) and occlusion (Figure 4).

Figure 3. Digital impression of the lower arch.

Figure 4. The 2 arches in centric relationship.

The materials for conventional impressions of upper and lower dental arches and occlusion were chosen. Standard

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impression trays and silicone were used. After this, the process of taking classic impressions and the occlusion relationship was carried out. For the case in Figure 2.5, addition curing silicone type President Putty and President Regular Body from Coltene (Coltene Holding Ag Switzerland) were used. Jet Blue Bite Fast Coltene (Coltene Holding Ag Switzerland) was used for occlusion impression.

Figure 5. Classic impressions and the Bite.

Figure 6. Plaster models.

The classic impressions arrive at the dental laboratory to obtain the plaster model (Figura 6), then scan it to get the virtual model to design the future dental restoration.

Working flow for the edentulous patients

For all edentulous patients, following the patient's history and examination, the treatment plan was established to rehabilitate the edentulous arch with removable total prosthesis.

For the first phase of the treatment plan, each patient benefited from a check-up and the presentation and acceptance of the treatment plan (Figure 7).

Figure 7. Initial phase.

The digital impression was taken by intraoral scanning with a Medit I700 scanner, consisting in maxilla jaw (Figure 8) and mandible jaw (Figure 9).

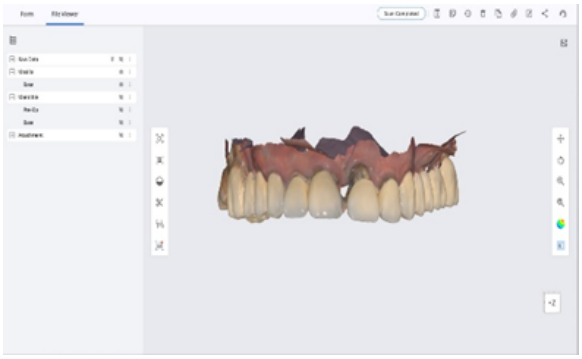

Figure 8. Digital impression of the upper arch.

In the case of completely edentulous patients, it is necessary for the intraoral scan to be supplemented with a classic impression to obtain the marginal areas and virtual model resulting from software overlay of intraoral

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scan and classic impression scan (Figure 9, Figure 10), as well as the scanning of a template (RIM) to establish the occlusion (Figure 11).

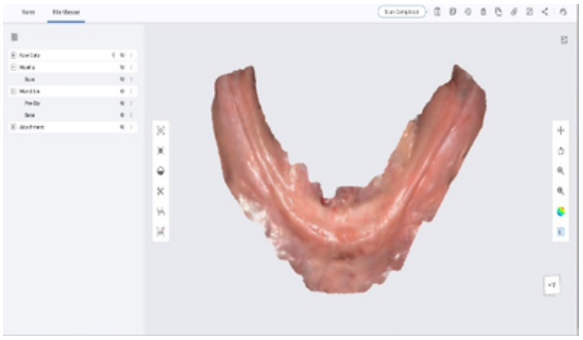

Figure 9. Digital impression of the lower arch.

Figure 9. Classic preliminary impresion scanning.

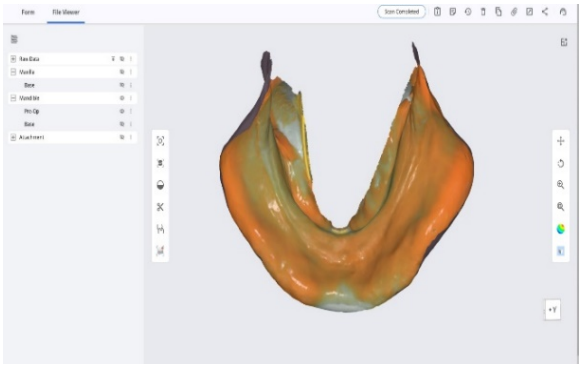

Figure 10. The virtual model.

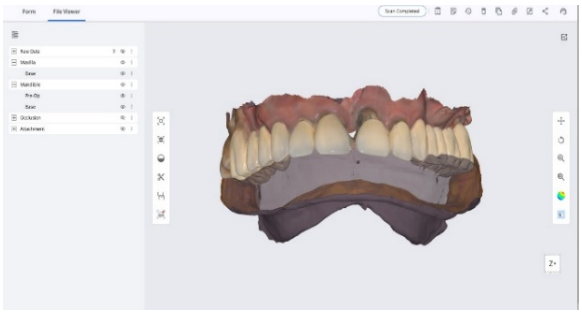

Figure 11. Virtual occlusion resulting from scanning the physical occlusion template (RIM).

To take impressions of the 2 arches, upper (Figure 12) and lower (Figure 13), using the classic method, standard impression trays and the material to be used are chosen. After this, the process of taking classic impressions and the occlusion relationship is carried out using wax template RIM (Figure 14).

Figure 12. Upper arch impression with putty and fluid silicone.

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Figure 13. Upper arch impression with fluid silicone.

Figure 14. Wax Template (RIM).

3. Results

The study included 24 patients, 12 dentate patients, and 12 patients with different types of total edentulism (one jaw mandibular or maxillary or both jaws). Patients included in the study were 12 men and 12 women, and in each group of dentate or edentulism, gender rapport was equal. The median age for the two groups (dentate and edentulous) was 45 for dentate (age between 35 and 55) and 75 for edentulous (age between 65 and 80).

During and after taking intraoral impressions using both the classic impression method and the digital method via intraoral scanning, in terms of perception and comfort generated for the patient, the digital impression via intraoral scanning produced a more positive perception regarding the impression phase in oral rehabilitation and greater ease compared to the impression taken using the classic impression method.

Regarding the execution time in the case of dentate patients, the digital impression method via intraoral scanning required a shorter execution time (20 ± 5.5 minutes), and the impression process via the classical method needed more time (30 ± 7.5 minutes).

Sending the digital impression to the dental laboratory has become easier, with the option of sending it electronically through a specific application or email. This step gives a vital time gain.

Storing the digital impression through intraoral scanning can be done electronically on a local storage device or in the storage space offered by some manufacturers without requiring physical storage space. In contrast, in the case of the classic impression, only the plaster model can be stored for a more extended period, in which case physical storage space is required.

Regarding the execution time of the impression of the edentulous patients, in the case of the digital impression by intraoral scanning, more time was needed (65 ± 10.5 minutes), the impression being taken quite difficult, requiring several attempts due to the lack of anatomical landmarks. In the case of the impression taken by the classical method, it needed a shorter time compared to the digital impression (55 ± 8.5 minutes).

The digital impression by direct intraoral scanning was not sufficient to fully record the

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limits of the mandibular edentulous prosthetic field, requiring an additional scan of the classical preliminary impression and the superimposition of this scan over the digital impression by direct intraoral scanning.

4. Discussions

Conventional impression techniques used to register the 3D geometry of dental arches have been used for more than two centuries. However, this traditional method is prone to errors as it involves using impression materials and dental stones susceptible to volumetric changes and possible damages during the transfer from the dental practitioner to the laboratory. This conventional method requires skill from the dental clinician, the dental technician and an excellent dental laboratory with sufficient expertise [15].

The introduction of the intraoral scanning devices and the development of CAD/CAM technology in the dental practice provide simplified treatment planning, easier case acceptance, better communication with laboratories, and significantly reduced operative time. Also, storage requirements are unnecessary, and treatment attendance has decreased. [16,17].

The technological advances both in software and hardware that intraoral scanners have benefited from in recent years allowed for accuracy as good or better than conventional impressions [18].

Digital intraoral scanning was considered for many years to be a clinically acceptable alternative to conventional impression techniques when dealing with crowns and short dental bridges as restorative options, and less so when a full-arch impression is needed, in which case the conventional impressions are preferred [3].

The defining characteristic of an intraoral scanner is accuracy, a combination of trueness and precision. According to the International Standard Organization (ISO) 5725:1 definition, trueness is defined as the "closeness of agreement between the arithmetic mean of a large number of test results and the true or accepted reference value". In contrast, the precision definition is "the closeness of agreement between different test results" [19,20].

Both early and most recent reviews that analyzed the marginal fit of dental crowns and bridges manufactured using conventional impressions versus digital impression technique show greater marginal accuracy in the latter group [21,22].

The scanning strategy is also a factor often quoted to have an essential role in the success of intraoral scanning, as the chosen strategy is likely to impact the accuracy of the digital scan [23].

According to some authors, the experience of the scanning operator is also a critical factor for the accuracy of the digital scan, as well as the size of the area to be scanned because the stitching process involved in this technology can affect the accuracy of the digital impressions, especially in the case of full-arch impressions [24-27].

The latest software and scanner versions have improved the accuracy levels, even for full dental arch scans [19].

Our study obtained similar results regarding the effects of the two impression methods. Thus, digital impressions by

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intraoral scanning, compared to classical impressions, have a reduced impact on the feeling of vomiting caused by patients, difficulty breathing caused by patients, stress, and anxiety caused by patients, and they generate better results in perception and comfort generated by patients.

While producing a removable complete denture using a digital impression by direct intraoral scanning, registration by the classical method is required to accurately determine the boundaries of the total edentulous prosthetic field, thus challenging the total digital manufacturing flow.

In terms of producing crowns and bridges on prepared teeth, digital impressions

through intraoral scanning have proven their effectiveness.

As for the impression time, it depends on each clinical situation. Thus, the scanning process of the completely edentulous mandible required more time because the edentulous field had an unfavorable anatomy, represented by a resorbed edentulous ridge. At the same time, the soft parts covered this edentulous ridge, requiring more scanning attempts.

Scanning the mandible to produce micro-prostheses was shorter than the time required to take the classic impression because the patient presented a pronounced vomiting sensation, thus becoming an unfavorable scenario for the impression using the classic method.

5. Conclusions

Intraoral digital impression techniques offer significant advantages over conventional methods that use impression material to increase patient comfort and improve communication between the patient, dental technician, and clinician. At the same time, it eliminates all error-prone stages related to the impression material and dental stone deformation, thereby resulting in superior accuracy.

References

1. Mörmann WH, Brandestini M, Lutz F, *The Cerec System: Computer-Assisted Preparation of Direct Ceramic Inlays in 1 Setting*, Quintessenz 1987; 38(3): 457-470
2. Tamini F, Hirayama H, *Digital Restorative Dentistry – A Guide to Materials, Equipment and Clinical Procedures*, Springer Nature Switzerland AG 2019.
3. Ahlholm P, Sipilä K, Vallittu P, Jakonen M, Kotiranta U. *Digital Versus Conventional Impressions in Fixed Prosthodontics: A Review*. J. Prosthodont. 2018, 27, 35–41.
4. Yuzbasioglu, E.; Kurt, H.; Turunc, R.; Bilir, H. *Comparison of Digital and Conventional Impression Techniques: Evaluation of Patients' Perception, Treatment Comfort, Effectiveness and Clinical Outcomes*. BMC Oral Health 2014, 14, 10.
5. Revilla-León, M.; Att, W.; Özcan, M.; Rubenstein, J. *Comparison of Conventional, Photogrammetry, and Intraoral Scanning Accuracy of Complete-Arch Implant Impression Procedures Evaluated with a Coordinate Measuring Machine*. J. Prosthet. Dent. 2021, 125, 470–478.
6. Flügge, T.; van der Meer, W.J.; Gonzalez, B.G.; Vach, K.; Wismeijer, D.; Wang, P. *The Accuracy of Different Dental Impression Techniques for Implant-Supported Dental Prostheses: A Systematic Review and Meta-Analysis*. Clin. Oral Implant. Res. 2018, 29 (Suppl. 16), 374–392.

 DOI: 10.58179/RJDR1405

7. Güth JF, Keul C, Stimmelmayr M, Beuer F, Edelhoff D. *Accuracy of digital models obtained by direct and indirect data capturing.* Clin Oral Investig. 2013; 17(4):1201-8.
8. Van der Meer WJ, Andriessen FS, Wismeijer D, Ren Y. *Application of intra-oral dental scanners in the digital workflow of implantology*. PLoS One. 2012;7(8):e43312.
9. Solarberrieta E, Otegi JR, Goicoechea N, Brizuela A, Pradies G. *Comparison of a conventional and virtual occlusal record.* J Prosthet Dent. 2015;114(1):92-7.
10. Mangano FG, Veronesi G, Hauschild U, Mijiritsky E, Mangano C. Trueness and Precision of Four Intraoral Scanners in Oral Implantology: A Comparative in Vitro Study. PLoS One. 2016 Sep 29;11(9):e0163107. doi: 10.1371/journal.pone.0163107.
11. Medina-Sotomayor P, Pascual-Moscardó A, Camps I. Accuracy of four digital scanners according to scanning strategy in complete-arch impressions. PLoS One. 2018 Sep 13;13(9):e0202916. doi: 10.1371/journal.pone.0202916. Erratum in: PLoS One. 2018 Dec 20;13(12):e0209883. doi: 10.1371/journal.pone.0209883.
12. Nedelcu R, Olsson P, Nyström I, Thor A. Finish line distinctness and accuracy in 7 intraoral scanners versus conventional impression: an in vitro descriptive comparison. BMC Oral Health. 2018 Feb 23;18(1):27. doi: 10.1186/s12903-018-0489-3.
13. Sanda M, Miyoshi K, Baba K. Trueness and precision of digital implant impressions by intraoral scanners: a literature review. Int J Implant Dent. 2021 Jul 27;7(1):97. doi: 10.1186/s40729-021-00352-9.
14. Serrano-Velasco D, Martin-Vacas A, Paz-Cortes MM, Giovannini G,Cintora-Lopez P, Aragoneses JM. 2023. Intraoral scanners in children: evaluation of the patient perception, reliability and reproducibility, and chairside time - a systematic review. Front Pediatr. 11:1213072. doi: 10.3389/fped.2023.1213072
15. Raphaël Richert, Alexis Goujat, Laurent Venet, Gilbert Viguie, Stéphane Viennot, Philip Robinson, Jean-Christophe Farges, Michel Fages, Maxime Ducret. *Intraoral Scanner Technologies: A Review to Make a Successful Impression*. J Healthc Eng. 2017; 2017: 8427595
16. Zimmermann M., Mehl A., Mörmann W. H., Reich S. *Intraoral Scanning Systems - A Current Overview*. *International Journal of Computerized Dentistry*. 2015;18(2):101–129.
17. Baheti M. J., Soni U. N., Gharat N. V., Mahagaonkar P., Khokhani R., Dash S. *Intra-oral scanners: a new eye in dentistry*. *Austin Journal of Orthopedics & Rheumatology*. 2015;2(3)
18. Zarbakhsh A., Jalalian E., Samiei N., Mahgoli M.H., Kaseb Ghane H. *Accuracy of Digital Impression Taking Using Intraoral Scanner versus the Conventional Technique*. Front. Dent. 2021;18:6. doi: 10.18502/fid.v18i6.5649.
19. Giovanni Giuliodori, Giorgio Rappelli, Luca Aquilanti, Stefano Di Carlo, Gerardo Pellegrino, Luigi Vito Stefanelli, Grecchi Francesco, Alessio Franchina. *Intraoral Scans of Full Dental Arches: An In Vitro Measurement Study of the Accuracy of Different Intraoral Scanners.* Int J Environ Res Public Health. 2023 Mar; 20(6): 4776.
20. ISO 5725-1:1994 (En); Accuracy (Trueness and Precision) of Measurement Methods and Results - Part 1: General Principles and Definitions. [(accessed on 19 August 2022)]. Available online: https://www.iso.org/obp/ui/#iso:std:iso:5725:-1:ed-1:v1:en
21. Chochlidakis, K.M.; Papaspyridakos, P.; Geminiani, A.; Chen, C.-J.; Feng, I.J.; Ercoli, C. *Digital versus Conventional Impressions for Fixed Prosthodontics: A Systematic Review and Meta-Analysis*. J. Prosthet. Dent. 2016, 116, 184–190.
22. Tabesh, M.; Nejatidanesh, F.; Savabi, G.; Davoudi, A.; Savabi, O.; Mirmohammadi, H. *Marginal Adaptation of Zirconia Complete-Coverage Fixed Dental Restorations Made from Digital Scans or Conventional Impressions: A Systematic*

Review and Meta-Analysis. J. Prosthet. Dent. 2021, 125, 603–610.
23. Passos L., Meiga S., Brigagão V., Street A. *Impact of Different Scanning Strategies on the Accuracy of Two Current Intraoral Scanning Systems in Complete-Arch Impressions: An in Vitro Study*. Int. J. Comput. Dent. 2019;22:307–319
24. Mennito A.S., Evans Z.P., Nash J., Bocklet C., Lauer Kelly A., Bacro T., Cayouette M., Ludlow M., Renne W.G. *Evaluation of the Trueness and Precision of Complete Arch Digital Impressions on a Human Maxilla Using Seven Different Intraoral Digital Impression Systems and a Laboratory Scanner*. J. Esthet. Restor. Dent. 2019;31:369–377.
25. Latham J., Ludlow M., Mennito A., Kelly A., Evans Z., Renne W. *Effect of Scan Pattern on Complete-Arch Scans with 4 Digital Scanners*. J. Prosthet. Dent. 2020;123:85–95. doi: 10.1016/j.prosdent.2019.02.008.
26. Favero R., Volpato A., Francesco M.D., Fiore A.D., Guazzo R., Favero L. *Accuracy of 3D Digital Modeling of Dental Arches*. Dental. Press. J. Orthod. 2019; 24:38e1–37e7.
27. Vág J., Nagy Z., Simon B., Mikolicz Á., Kövér E., Mennito A., Evans Z., Renne W. *A Novel Method for Complex Three-Dimensional Evaluation of Intraoral Scanner Accuracy*. Int. J. Comput. Dent. 2019;22:239–249.

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Data will be provided on request.

Ethics statement

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