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REVIEW

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Antibiotics for treatment of apical periodontitis, indication or contraindication

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Abstract

Background Apical periodontitis as an endodontic diagnosis has attracted attention for the close relationship between the periodontal nature and the endodontic nature that this pathology represents. The appearance of pathology in periodontal tissues, but originating from the infected canal of the affected tooth, is caused by the passage of pulpal infection–inflammation products only between the apical foramen toward the periodontal tissues positioned at the exit of the tooth canal. Depending on the morphology of the canal, it can be one inflamed area, or several that form a whole, if the pulp has terminal branches, like "*river delta*," in its apical exit.

Main body of the abstract The study aims to evaluate the clinical significance whether to treat or not with antibiotics of apical periodontitis. This study aims to look at this pathology from the perspective of the articles already published in the literature and after processing the conclusions of all the articles, come up with current recommendations on the treatment or not with antibiotics of the clinical cases presented with the pathology of the apical periodontium.

Results The classification of apical periodontitis occurs depending on the clinical signs visible with radiographs and the objective and subjective complaints of the patient. Regardless of subclassifications of apical periodontitis, the cause is bacteria or symbiosis of bacteria causing pulpitis, so as in any bacterial infection there is a tendency to treat them with antibiotics locally rather than in a systemic way, as long as the infection does not cause systemic symptoms such as fever, or massive swelling of the affected area.

Short conclusion From the analysis of the collected information, it is clear that the trend for treatment of apical periodontitis in the future does not lie in the application of antibiotics, but rather in irrigation solutions or the use of devices for the purpose of disinfecting the canal affected by the pathology. However, in no case is it indicated to eliminate the mechanochemical canal cleaning protocol before applying any type of treatment methodology.

Keywords Apical periodontitis, Antibiotics, Endodontic treatment, Penicillin amoxicillin

Background

Periradicular lesions have a pulpal origin, but between the clinical signs of the manifestation, data and histological changes, symptoms and their duration, there is no logical connection for the correct application of the classification according to acute and chronic terminology.

Apical periodontitis is classified as symptomatic (acute) and asymptomatic (chronic). The names symptomatic and asymptomatic are based on the description of the clinical condition of the tooth affected by the pathology, evaluated by specific clinical and radiographic manifestations (Czarnecki and Schilder 1979; Adriaens et al. 1988a, 1988b).

Symptomatic apical periodontitis is localized inflammation in the periodontal ligament, induced by the mechanical–physical exit of irritants from the inflamed pulp of the tooth to the periodontal ligament, through the apical foramen. Caution, irritants can be bacteria or bacterial toxins of the inflamed pulp, pulpal remnants

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mechanically protruding beyond the apex, pulpal disinfectant medications or even physical irritation of the periodontal ligament. It is preceded by pulpitis or necrosis of the tooth (Adriaens et al. 1988a; Saunders and Saunders 1990).

Asymptomatic apical periodontitis can be preceded by symptomatic apical periodontitis, but is usually caused by incorrect endodontic root canal treatment. Necrotic pulp releases pathogens in reduced amounts, but in the clinical duration of the pathology, the amount of pathogenic products is high. Since it is a long-term pathology, the periradicular bone is given time to react with resorption around the affected canal, without having the sensation of pressure in the position we are talking about. The main cause is pulpal necrosis (Adriaens et al. 1988b; Ray and Trope 1995; Torabinejad and Kiger 1985; Andreasen et al. 2002; Ricucci and Bergenholtz 2004).

Symptomatic apical periodontitis, the primary diagnostic element is pain on percussion. Pain may be mild to moderate when the tooth meets the antagonist. The vitality test can be positive or negative, since the origin of the pathology is pulpitis or necrosis (Ray and Trope 1995).

Asymptomatic apical periodontitis is not accompanied by pain on percussion. This periradicular lesion develops and enlarges without subjective signs and symptoms of the patient. The vitality test is negative since the origin of the lesion is always the presence of pulpal necrosis of the affected tooth.

Symptomatic apical periodontitis regardless of the nature of the stimulus, the irritant is of bacterial or physical–mechanical origin, is accompanied by the release of inflammatory mediators in the periodontal ligament. The latter has its limits of the possibility of expansion within the rigid contours of the space between the cementum and the surrounding bone of the periodontal ligament. The increase in infection–inflammation products leads to mechanical compression of the nerve endings of the periodontal ligament, which clearly justifies the periradicular pain accompanying the lesion (Adriaens et al. 1988a; Ray and Trope 1995; Ricucci and Bergenholtz 2004; Jansson et al. 1995; Rotstein and Simon 2006).

Asymptomatic apical periodontitis is prolonged inflammation in time and products such as prostaglandin E2 have caused bone resorption to leave the necessary space for the positioning and localization of inflammatory mediators. The obvious difference when compared to symptomatic apical periodontitis is the time and dosage effect or minimal bacterial overload against the periodontal ligament.

Symptomatic apical periodontitis on radiographs is associated with visible thickening of the periodontal ligament's space, while asymptomatic apical periodontitis has radiolucent periradicular changes with lamina dura resorption and radicular bone destruction. *Asymptomatic periradicular periodontitis* is histologically classified as granuloma or periradicular cyst. The radiographic variant of asymptomatic apical periodontitis is condensing osteitis, which again begins as periradicular inflammation, but with local osteoblastic and osteoclastic activation (Czarnecki and Schilder 1979; Ray and Trope 1995; Jansson et al. 1995; Simon et al. 1972).

The treatment for chronic pulpalgia is well defined, since when it is known where it comes from and where the infection originates, it is understood that it is necessary to intervene in that area and remove the cause. In cases of periapical periodontitis, regardless of the subclassifications of this pathology, the treatment is extirpation of the pulp and adequate endodontic therapy, if the tooth can be treated. Here, there may be clinical cases where pulp chamber intervention or endodontic treatment steps cannot be performed since the tooth cannot be saved from extraction, even if endodontic treatment is performed (Saunders and Saunders 1990; Ricucci and Bergenholtz 2004; Simon et al. 1972). The basic rules or principles when extracting a tooth can be mentioned, such as when less than apical third of the tooth is covered by bone, when furcation exposure cannot be treated with periodontal surgery, etc. Before any endodontic treatment, the indicated technique of dental anesthesia should be performed, if the tooth still has vital pulp, but in cases of periradicular periodontitis, this does not happen.

Endodontic treatment for symptomatic periapical periodontitis includes rather the part of preventing its causation by the dentist. Any endodontic root canal irrigant is highly toxic to the periradicular tissues, so care must be taken not to exceed the apical foramen. But even if periapical periodontitis occurs, the primary care for the patient is not to leave him in pain, and after adequate anesthesia with anesthetic, the tooth should be extracted from the occlusion, can be fixed with fingers to prevent further trauma, and the chamber and canals should be cleaned of any liquid content (Torabinejad and Kiger 1985; Arruda et al. 2018). Determining the working length is very important as it is attempted to drill the apical foramen beyond this working length and thus release blood and fluids that reduce periradicular pressure. The combination of hydrocortisone with neomycin, a corticosteroid with an anti-inflammatory effect and neomycin with an antibacterial effect, is recommended as a treatment medication. It is attempted to extract this content with lentulo out of the canal to act with a soothing effect on the periradicular tissues. The canal should not be filled completely with this type of paste, as it must leave room for edema and the flow of fluids beyond the canal (Adriaens et al. 1988a; Ray and Trope 1995; Torabinejad

and Kiger 1985; Ricucci and Bergenholtz 2004; Arruda et al. 2018).

If the patient still has pain after the anesthesia is released, he is called back to the dental office and the procedure is repeated. Care must be taken with occlusion control. If the pain persists at night, it is recommended that the patient be instructed to remove the temporary filling himself. In these cases, it is also recommended to give systemic antibiotics and anti-inflammatories such as ibuprofen, naproxen and piroxicam for 4 days. Asymptomatic apical periodontitis is indicated for endodontic treatment that can be followed by periradicular surgery, in cases where this is indicated (Ray and Trope 1995; Andreasen et al. 2002).

Main text

The study is oriented around the collection of data already published on the treatment method of apical periodontitis and further the treatment method according to the specifics of its classification into symptomatic apical periodontitis and asymptomatic apical periodontitis. The study is of the review type with the tendency to see the evolution of the concept of antibiotic treatment, given locally or systemically. At the time of the appearance of high bacterial resistance in the population, to antibiotics given in mass, by prescription, it is attempted to find the correct indications for the systemic administration of antibiotics for this pathology.

The collection of information should be oriented around finding the trend of scientific research in this direction, toward how these data are sought through the results of review-type studies, or studies based on experiments performed in vitro or in vivo on the teeth affected by this pathology.

Antibiotic resistance and the way it has evolved in the selected stages of the years in this study, is another goal in itself for the study, to connect it closely with the evolution of the concept of how this pathology appears and what are its causes. The marketing of different companies producing antibiotics in the form of ready-made pastes, or the tendency to use combinations of antibiotics mixed immediately on the dental chair, in the presence of the patient with the pathology of the apical periodontium, and the evaluation of this tendency is another goal of this the study (Arruda et al. 2018; Morsy et al. 2018; Karataş et al. 2020; Wolf et al. 2019; AbdurRahman et al. 2019; Ali et al. 2020; Zandi et al. 2016; Chu et al. 2006; Samir Abouelenien et al. 2018; Ehrmann et al. 2003; Malkhassian et al. 2009; Garcez et al. 2010; Silva et al. 2017; Meschi et al. 2018; Fouad et al. 1996; Danin et al. 2003; Fava 1998; Walton and Chiappinelli 1993; Fahim et al. 2022; Molander et al. 1990; Bhangdia et al. 2013; Lindeboom et al. 2005; Paterson and Curzon 1993).

The electronic search was performed in PubMed with the keywords: apical periodontitis, antibiotics and endodontic treatment, with several steps in word combinations. The time interval of the research is 33 years, with articles published in PubMed about apical periodontitis and the treatment of this pathology. The period from 1990 to 2023 was chosen due to the fact that 1990 marks the year of certification of the antibiotic clarithromycin for application in the population. It is emphasized that this antibiotic is among the most selected in cases of endodontic infections (Greenwood 2008; Fischer and Ganellin 2006).

The filters or the selected criteria are: abstract and full text, clinical trial, English language and publications within the time interval of 10 years. After analyzing the abstracts and articles collected up to this stage, the criteria for inclusion and exclusion in the analysis were selected. The inclusion criteria in the analysis were all articles that directly evaluated the impact of antibiotic treatment or another endodontic treatment method versus the traditional method of mechanochemical root canal treatment.

The exclusion criteria were:

Keywords used with the prefix "no" were apexification and vital pulp treatment. Expressed in words, the purpose of selecting these words was to exclude with the criteria of non-inclusion in the study:

1. Studies on endodontic treatments of apical periodontitis in non-apexified teeth.
2. Studies aimed at vital pulp treatments in cases of pulpitis without bacterial infection.
3. Studies about trauma from occlusion, as an element that initially causes symptomatic apical periodontitis.

A total of 23 articles were selected, of which 9 articles were not taken for further evaluation as they did not meet 1 or some of the following criteria:

1. Articles that do not mention the application of antibiotics, but simply the antibacterial effect of other methods of treatment of apical periodontitis (4 articles)
2. Articles about clinical signs of pathology and their assessment, not about the antibacterial effect of antibiotic treatment (1 article)
3. Articles on antibiotic prophylaxis of the pathology in question (1 article)
4. Articles on irrigation solutions and their antibacterial effect in cases of apical periodontitis (3 articles).

At this stage, 14 articles were selected as part of the basic articles included in the study.

Table 1 Selected articles in ascending order of the year of publication, accompanied by the data collected in the study

No.	Study authors	Pathology	Tooth sample		Medicament	Group control
			≤ 50	≥ 51		
1	Molander et al. (1990)	PA*	25		Clindamycin	Calcium hydroxide
2	Walton and Chiappinelli (1993)	PAA*		80	Penicillin	Placebo
3	Paterson and Curzon (1993)	PAS*	30		Amoxicillin Penicillin	Placebo
4	Fouad et al. (1996)	PAS	35		Penicillin	Placebo
5	Fava (1998)	PAS	48		Minocycline corticosteroid	Calcium hydroxide
6	Danin et al. (2003)	PA	22		Linezolid	Placebo
7	Ehrmann et al. (2003)	PAS		221	Ledermix	Calcium hydroxide
8	Chu et al. (2006)	PA		88	Ledermix Streptomycin	Calcium hydroxide
9	Bhangdia et al. (2013)	PAA	20		Metronidazole 3–0.5%	–
10	Arruda et al. (2018)	PAA		70	Minocycline Metronidazole Ciprofloxacin	Calcium hydroxide
11	Samir Abouelenien et al. (2018)	PA	36		Minocycline Metronidazole	Calcium hydroxide
12	AbdurRahman et al. (2019)	PA	44		Minocycline Metronidazole Ciprofloxacin	Calcium hydroxide Placebo
13	Karataş et al. (2020)	PAA		54	Ciprofloxacin	Calcium hydroxide Ibuprofen
14	Ali et al. (2020)	PAS		120	Minocycline Metronidazole Ciprofloxacin	Placebo

*Abbreviations of diagnoses used in this table and in the following tables are as follows: *PA* Apical periodontitis; *PAS* Symptomatic apical periodontitis; *PAA* Asymptomatic apical periodontitis

Table 2 Data on the method of application of antibiotics, the final effectiveness, accompanied by data on the sample of teeth taken in the study

Diagnosis	Tooth sample		Antibiotics		Effectiveness		Total Nr.—%
	≤ 50 (%)	≥ 51 (%)	Mixed at the moment (%)	Prefabricated (%)	Positive (%)	Negative (%)	
PA	4 (29)	1 (7)	4 (29)	1 (7)	1 (7)	4 (29)	5 (36%)
PAS	3 (21)	2 (14)	4 (29)	1 (7)	2 (14)	3 (21)	5 (36%)
PAA	2 (14)	2 (14)	4 (29)	–	3 (21)	1 (7)	4 (29%)
Total	9 (64)	5 (36)	12 (86)	2 (14)	6 (36)	8 (57)	14

Results

The results of processing the collected data are presented according to the tables below. The trend of articles on the treatment of apical periodontitis is presented in Table 1, accompanied by data on what was studied in the published articles. In Table 1, the articles are presented according to the earliest year of publication along with the type of antibiotic indicated based on the study conducted depending on the sample of teeth included in the study. In Table 2, the articles are divided depending on the type of antibiotic mixture used, which means whether the antibiotic was a factory-made paste, or a paste mixed by the dentist himself using the indicated percentages.

Table 3 presents the antibiotics or combination of antibiotics that are specifically indicated according to periapical symptomatology. The data of this table are associated with the data of Table 4, reflecting the years of production of pastes with antibiotics, depending on the year of publication of the article. In Table 5, the applied

Table 3 Antibiotics or combinations of antibiotics recommended or proven to be effective in the treatment of apical periodontitis, among the articles selected in the study

	PA (%)	PAS (%)	PAA (%)	Total (%)
Penicillin amoxicillin		1 (7)		1 (7)
Metronidazole			1 (7)	1 (7)
Clindamycin	1 (7)			1 (7)
Minocycline–Metronidazole–Ciprofloxacin	2 (14)	2 (14)	1 (7)	5 (36)
Ciprofloxacin			1 (7)	1 (7)
Ledermix	1 (7)	1 (7)		2 (14)
Penicillin		1 (7)	1 (7)	2 (14)
Linezolit	1 (7)			1 (7)
Total	5 (36)	5 (36)	4 (29)	14 (100)

Table 4 Distribution of the articles included in the study depending on the years of publication and the type of antibiotic used

	-2000	2001–2011	2012–2022	Total (%)
Penicillin amoxicillin	1	–	–	1 (7)
Metronidazole		–	1 (7%)	1 (7)
Clindamycin	1 (7%)	–	–	1 (7)
Minocycline–Metronidazole–Ciprofloxacin	1 (7%)	–	4 (29%)	5 (36)
Ciprofloxacin	–	–	1 (7%)	1 (7)
Ledermix	–	2 (14%)	–	2 (14)
Penicillin	2 (14%)	–	–	2 (14)
Linezolit	1 (7%)	–	–	1 (7)
Total	6 (43%)	2 (14%)	6 (43%)	14 (100)

antibiotics are evaluated based on the positive effects they had for the treatment of apical periodontitis, according to the diagnosis of symptomatic or asymptomatic apical periodontitis.

The way in which the positive effect of the antibiotics used for the treatment of periapical infections was evaluated is shown in Table 6, where the 3 most frequent methods are distinguished, such as taking a bacterial sample, postoperative pain and laboratory analyses. In Table 7, these antibiotics and their positive effects are classified on how the positive effects are expressed in the clinical case, accompanied by the percentage of articles that indicate the presence of negative effects of antibiotic application.

Discussions

The part that is included in the scope of this study, from the initial 23 articles, consisted of only 14 articles, that is, about 60% of the literature (Arruda et al. 2018; Morsy et al. 2018; Karataş et al. 2020; Wolf et al. 2019; AbdurRahman et al. 2019; Ali et al. 2020; Zandi et al. 2016; Chu et al. 2006; Samir Abouelenien et al. 2018; Ehrmann et al. 2003; Malkhassian et al. 2009; Garcez et al. 2010; Silva et al. 2017; Meschi et al. 2018; Fouad et al. 1996; Danin et al. 2003; Fava 1998; Walton and Chiappinelli 1993; Fahim et al. 2022; Molander et al. 1990; Bhangdia et al. 2013; Lindeboom et al. 2005; Paterson and Curzon 1993). The rest of the articles which discussed apical periodontitis and its treatment carried out the treatment for this pathology with methodologies or medications and solutions other than antibiotics or containing antibiotics. These devices or solutions

Table 5 Results of the articles included in the review about the effect of the application of antibiotics for the treatment of apical periodontitis

No.	Study authors	Pathology		Medicament	Conclusions
1	Molander et al. (1990)	PA		Clindamycin	2 distance application sessions 7 days There are no advantages!
2	Walton and Chiappinelli (1993)		PAA	Penicillin	There are no advantages!
3	Paterson and Curzon (1993)		PAS	Amoxicillin Penicillin	Amoxicillin more effective than penicillin!
4	Fouad et al. (1996)		PAS	Penicillin	There are no advantages!
5	Fava (1998)		PAS	Minocycline corticosteroid	There are no advantages!
6	Danin et al. (2003)	PA		Linezolid	The tissue indicator Il-1RA is an indicator of the effectiveness of the antibiotic
7	Ehrmann et al. (2003)		PAS	Ledermix	Faster pain reduction compared to calcium hydroxide
8	Chu et al. (2006)	PA		Ledermix Streptomycin	Does not significantly reduce gram + facultative anaerobic cocci!
9	Bhangdia et al. (2013)		PAA	Metronidazole 3–0.5%	3% w/v more effective than 0.5% w/v against *E. faecal*
10	Arruda et al. (2018)		PAA	1 mg/ml antibiotic paste Minocycline metronidazole Ciprofloxacin	Positive effect after 1 week placed inside the channel!
11	Samir Abouelenien et al. (2018)	PA		Minocycline metronidazole	Postoperative pain is reduced despite the canal being treated only with excision!
12	AbdurRahman et al. (2019)	PA		1 mg/ml antibiotic paste Minocycline metronidazole Ciprofloxacin	Some resets after 1, 2, 3 days, 1 week, neutral effect!
13	Karataş et al. (2020)		PAA	Ciprofloxacin 50 mg + 950 mg calcium hydroxide + 1 mL Propylene glycol	Positive effects after placement with = duration 1 week 1 mm shorter than working length!
14	Ali et al. (2020)		PAS	Minocycline metronidazole Ciprofloxacin	Antibiotic paste has the same effect as calcium hydroxide—dexamethasone!

Table 6 Results of the articles included in the review, according to the method and methodology of analyzing the effectiveness of antibiotics

Diagnosis	Bacterial sample immediately—after 1 week (%)	Postoperative pain 24, 48, 72, 1 week (%)	Lab analysis (%)	Total (%)
PA	3 (21)	2 (14)	1 (7)	6 (43)
PAS	–	5 (36)	–	5 (36)
PAA	2 (14)	1 (7)	–	3 (21)
Total	5 (36)	7 (50)	1 (7)	14 (100)

Table 7 Results about the application of antibiotics divided as positive and negative, where the positive results are divided according to the element that leads to clinical success

Diagnosis	Positive results				Negative results (%)
	% of antibiotics	Duration (%)	Technical protocol (%)	Protocol organization (%)	
PA	–	–	1 (7)	1 (7)	4 (28)
PAS	1 (7)	–	–	1 (7)	3 (21)
PAA	1 (67)	1 (7)	1 (7)	–	–
Total	2 (14)	1 (7)	2 (14)	2 (14)	7(50)

aim to disinfect the channel affected by the mentioned pathology. Among these treatment methods, the application of chlorhexidine as a canal irrigating rinse prevails, followed by innovative methods such as photodynamic or laser application. Importantly, despite the different treatment methodology in none of the 23 articles selected from the electronic search based on the combination of keywords, the clinical importance of treatment with pulpal extirpation, followed by mechanical and chemical treatment of the root canal, is not abandoned in the affected tooth (Morsy et al. 2018; Wolf et al. 2019; Zandi et al. 2016; Malkhassian et al. 2009).

The part of the articles discussing the apical periodontium, without specifics regarding the clinical subdivisions of this pathology, according to the symptomatic and asymptomatic classification, comprised about 40% of the selected articles (Arruda et al. 2018; AbdurRahman et al. 2019; Chu et al. 2006; Samir Abouelenien et al. 2018; Malkhassian et al. 2009; Danin et al. 2003; Molander et al. 1990). 40% of the articles discuss symptomatic periodontitis (Ali et al. 2020; Ehrmann et al. 2003; Fouad et al. 1996; Fava 1998; Paterson and Curzon 1993) and 20% for the asymptomatic one (Karataş et al. 2020; Walton and Chiappinelli 1993; Bhangdia et al. 2013). In about 64% of the articles, the samples where the study was applied are below 50 teeth—minimum amount, and in 36% of the articles for the application of the methodology according to the studies, they were applied to larger samples of teeth—more than 50 teeth.

Only 14% of the articles emphasize the application of pastes with pre-prepared antibiotics (Chu et al. 2006; Ehrmann et al. 2003), and 86% of the articles talk about the method of mixing and dosing that should be controlled by the dentist on the dental chair.

Medicinal treatment of apical periodontitis with antibiotic paste in root canals does not bring advantages compared to calcium hydroxide or placebo (simply placing a cotton roll in the canal) is supported by 57% of articles (AbdurRahman et al. 2019; Ali et al. 2020; Ehrmann et al. 2003; Fouad et al. 1996; Danin et al. 2003; Walton and Chiappinelli 1993).

The remaining part talks about easily recognizable advantages in the treatment of apical periodontitis, by means of antibiotics and placing them as a paste inside the affected canal.

Any endodontic drug paste, like any other pharmaceutical product at any product launch, will be accompanied by appropriate marketing. Therefore, the table about antibiotics ready or mixed by the dentist himself also takes value from the marketing and from the corresponding year of production of Ledermix. The period of years up to the year 2000 highlights the need for the application of antibiotics and mainly of 1 of the types of antibiotics, but not of their combination. The 2001–2011 band includes articles that emphasize pharmaceutical names of endodontic products, such as Ledermix, Septodont, etc. Ledermix është pastë që përmban triamcinolon dhe demeclocycline me aktivitet antiinflamator (Chu et al. 2006; Ehrmann et al. 2003).

The advantages or disadvantages of the application of these medications in the period of 2012–2022, in the published articles, bring the need for the combination of antibiotics, given that the oral flora that causes apical periodontitis, regardless of the subdivisions of this pathology, is diverse, including G-, facultative anaerobic, or obligate aerobic, cocci or rods. Among the articles included in this review, only 1 article came out with concrete names of bacteria where the antibiotic used acts, which is very specific for the destruction or reduction in colonies or the colony-forming ability of the bacterium itself.

This article talks about E. faecalis with a tendency to find the bactericidal antibiotic (Bhangdia et al. 2013). The manner in which apical periodontitis is analyzed and the response to applications by performing analyses with a different control group in % of the antibiotic, compared to the application of calcium hydroxide, or simply placebo, showed the trend of the published literature about the clinical evaluation of the antibiotic paste with only calcium hydroxide.

Conclusion

Analyzing the collected information, it is clear that the trend for the treatment of apical periodontitis in the future does not rely on the application of antibiotics, but rather on irrigation solutions or the use of devices for the purpose of disinfecting the channel affected by the pathology. However, in no case is it indicated to eliminate the mechanochemical canal cleaning protocol before applying any type of treatment methodology.

Studies about the treatment of apical periodontitis should be performed on larger samples of teeth or canals included in the study. It is more recommended to use antibiotic compound pastes that contain two or three antibiotics that are instantly mixed near the dental chair, rather than antibiotics in the form of ready-made pastes.

The clinical success of applying antibiotic pastes and the clinical success of applying calcium hydroxide as a treatment step for apical periodontitis are the same.

Abbreviations

PA	Apical periodontitis
PAS	Symptomatic apical periodontitis
PAA	Asymptomatic apical periodontitis

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Author contributions

IR collected the scientific data and wrote the manuscript. SH and NA revised and edited the manuscript. Literature research was conducted by IR and NA. SH and VO collected the scientific data. All authors read and approved the final manuscript.

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Availability of data and materials

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Declarations

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Consent for publication

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Competing interests

The authors declare that they have no competing interests.

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