CONCISE REVIEW

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Worldwide pattern of antibiotic prescription in endodontic infections

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Background: Odontogenic infections, and especially endodontic infections, are polymicrobial, involving a combination of Gram-positive and Gram-negative facultative anaerobes and strictly anaerobic bacteria. Therefore, antibiotics can be used as an adjunct to endodontic treatment. However, most chronic and even acute endodontic infections can be successfully managed by disinfection of the root-canal system, which eliminates the source of infection, followed by abscess drainage or tooth extraction, without the need for antibiotics. The literature provides evidence of inadequate prescribing practices by dentists. The aim of this concise review was to analyse the worldwide pattern of antibiotic prescription in endodontic infections. **Methods:** Comprehensive searches were conducted in MEDLINE/PubMed, Wiley Online Database, Web of Science and Scopus. The databases were searched up to 13 March 2016 for studies in which dentists used systemic antibiotics to treat endodontic lesions and which reported data on the type of antibiotic prescribed and on the diagnosis of the endodontic disease treated. **Results:** The electronic and hand searches identified 69 titles, of which 25 were included in the final analysis. Amoxicillin was reported as the drug of choice for endodontic infections in most countries, and clindamycin and erythromycin were the choice for patients allergic to penicillin. Dentists worldwide prescribe antibiotics for non-indicated conditions, such as pulpitis. **Conclusion:** Antibiotics are overprescribed for the management of endodontic infections. It is necessary to improve antibiotic-prescribing habits in the treatment of endodontic infections, as well as to introduce educational initiatives to encourage the coherent and proper use of antibiotics in such conditions.

Key words: *Antibiotics prescription, pulpitis, apical periodontitis*

INTRODUCTION

Alexander Fleming discovered the first antibiotic, penicillin, in 1928. Florey, in 1940, introduced the use of antibiotics to clinical practice. Since then, dentists have used antibiotics widely. However, whereas many bacteria were initially found to be sensitive to different types of antibiotics, there has been a continuing appearance of antibiotic-resistant strains[1]. Antibiotic resistance is tolerance of a microorganism to an antibiotic that was initially effective for treatment of infections caused by that microorganism. It has been noticed that some bacteria, including those implicated in apical periodontitis[2], are developing resistance to most antibiotics currently available. Taking into account that dentists prescribe approximately 10% of all antibiotics commonly used, the impact of dentists in antimicrobial resistance is considerable[3]. After analgesics, antibiotics are the drugs most commonly prescribed by dentists[4]. A survey carried out in the UK in 2004 revealed that 40% of general dental practitioners prescribed antibiotics three times per week, and 15% prescribed them on a daily basis[1]. Nevertheless, it has been documented that such prescribing habits are either inappropriate or superfluous. Recently, it has been highlighted that the literature provides evidence of erroneous prescribing practices by dentists for a number of reasons, ranging from inadequate knowledge to social factors[5].

Odontogenic infections, and especially endodontic infections, are polymicrobial, involving a combination of Gram-positive and Gram-negative facultative anaerobes and strictly anaerobic bacteria[6,7]. Therefore, systemic antibiotics can be used as an adjunct to endodontic clinical treatment whenever the host response cannot contain the infection[8], such as in cases of persistent or systemic infections and in immunocompromised patients. The prescription of

antibiotics influenced by patient demand or by the expectation of referring dentists is inappropriate[9].

The aim of this review was to analyse the worldwide pattern of prescription of antibiotics by dentists for endodontic infections.

MATERIALS AND METHODS

The question addressed in this review was: What is the worldwide pattern of antibiotics prescription by dentists in endodontic infections? The search strategy was as follows. Searches of MEDLINE/PubMed, Wiley Online Database, Web of Science and Scopus were performed using the following combination of Mesh terms and key words: (antibiotic OR antibacterial agents) AND (dentist OR endodontist) AND (prescription OR inappropriate prescribing OR prescription drug misuse OR drug overuse OR prescription drug overuse) AND (dental pulp diseases OR pulpitis OR dental pulp necrosis OR periapical diseases OR periapical periodontitis OR periapical abscess OR apical periodontitis). The bibliography of all relevant papers was hand-searched.

Three investigators (J.M-G., M.C.J-S. and J.J.S-E.) screened the titles and abstracts of all articles identified in the electronic and manual searches, according to the following inclusion criteria: (i) studies published from 1 January 1996 to 13 March 2016 (there were no restrictions according to sample age, specific features or study design); and (ii) articles reporting data on the type of antibiotic prescribed and the diagnosis of the treated endodontic disease. Articles that did not meet the inclusion criteria were excluded. All remaining articles were obtained and the full text was reviewed independently by four reviewers (E.V-O., I.C-G., J.J.S-M. and J.J.S-E), who included the studies investigating the antibiotic-prescribing patterns in the management of pulpitis and apical periodontitis. In the event of disagreement between authors, articles were discussed until consensus was reached. Data were extracted (E.V-O. and J.J.S-E.), synthesised and analysed. For each study, the following parameters were recorded: prescriber; country; diagnosis of endodontic diseases treated; first- and second-choice antibiotic; antibiotic choice in penicillin-allergic patients; duration of treatment; year of publication; and evidence level, determined according to guidelines provided by The Centre for Evidence-Based Medicine at Oxford[10].

RESULTS

The electronic and hand searches identified 69 titles (*Figure 1*). Duplicate references (20 items) and articles published before 1996 (four items) were discarded. A subsequent search through the titles and abstracts of the remaining 45 records revealed 31 articles for full-text reading. At this level, six studies were excluded because they did not provide data on the diagnosis of endodontic diseases treated[11–16]. In the final analysis, 25 studies were included. *Table 1* shows studies according to continent, and summarises prescribers, diagnosis of endodontic diseases, first- and second-choice antibiotics, antibiotic choice in penicillin-allergic patients, treatment duration, publication year and study evidence level[10].

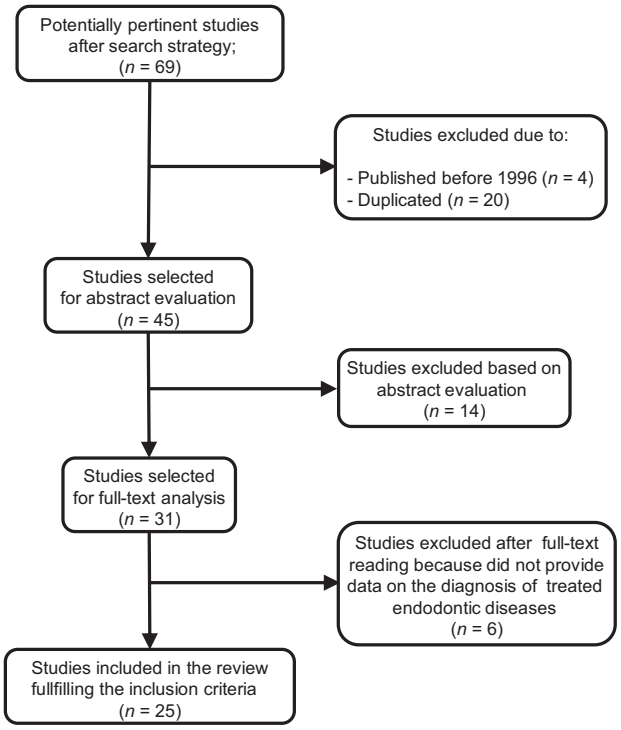

Figure 1. Flow chart showing the selection process for the studies included in the review.

North America

Early surveys to investigate the antibiotic-prescription pattern in the treatment of pulpitis and apical periodontitis were carried out in the United States, most of them amongst endodontists. Dorn *et al.*[17] carried out several surveys analysing the use of antibiotics by diplomates of the American Board of Endodontists in the treatment of endodontic infections. Swelling and lack of drainage through the canal were the main reasons to prescribe antibiotics, with necrotic pulp with diffuse swelling and no drainage being the condition for which the highest percentage of antibiotics were prescribed (87.6%)[17]. A decade later, in 1990, antibiotic-prescription habits could be broken down into three categories: prescription of antibiotics for vital pulps (3.5–13.7% of dentists); prescription of antibiotics when the pulp is non-vital and there is no

Table 1 Pattern of antibiotic prescription by dentists in different regions and countries

Region and Country	P	IP	IP-AP	NP-AP 1	NP-AP 2	NP-AP 3	NP-AP 4	First-choice AB	Second-choice AB	AB in allergic patient	Duration (days)*	Year and reference	Evidence level (10)
North America													
USA	EN	9.3	25.4	35.7	67.3	29.2	96.6	Penicillin VK	Amoxicillin	Erythromycin	–	1996 (20)	D
USA	GP	23.2	51.8	35.1	61.6	62.5	94.9	Penicillin VK	Amoxicillin	Erythromycin	–	1996 (20)	D
USA	EN	3.5	13.3	18.	53.9	11.9	99.2	Penicillin VK	Clindamycin	Clindamycin	7.6 ± 1.7	2002 (9)	D
USA	PD	2	32	42	68	39	99	Amoxicillin	Penicillin VK	–		2013 (19)	D
Europe													
UK	GP	12.5		69		26	90	Amoxicillin	Penicillin VK	Metronidazole	5 (3–10)	2000 (21)	D
Turkey	GP	100		83.3		–	–	Ampicillin	Amoxicillin	–	–	2000 (29)	D
UK	GP	74	–	23.2	–	75	100	Amoxicillin	Amoxicillin/metronidazole	Erythromycin	–	2001 (23)	D
UK	GP	39	44.4	68.8		–	84.8	Amoxicillin	Metronidazole	–	–	2008 (22)	D
Spain	EN	11.4	28.6	14.3	52.9	21.4	94.3	Amoxicillin	Metronidazole/spiramicyn	Clindamycin	6.8 ± 1.8	2009 (26)	D
Belgium	GP	5.9	–	–	–	–	82.7	Amoxicillin	Clindamycin	Erythromycin	–	2009 (24)	D
Lithuania	GP	2	–	–	60	–	84	Amoxicillin	Penicillin VK	–		2010 (25)	D
Spain	DS	31.5	54.3	30.7	70.9	59.8	94.5	Amoxicillin	Clindamycin	Clindamycin	7.0 ± 1.0	2010 (27)	D
Turkey	GP	21		21.7			41	Amoxicillin	Clindamycin	Clindamycin		2013 (27)	D
Croatia	GP	46		–	–	–	85	Amoxicillin	Clindamycin	Clindamycin	6.4 ± 1.6	2015 (30)	D
Asia													
Kuwait	GP	19.6	46.4	25.0	–	–	85.1	Amoxicillin	Penicillin VK	Erythromycin	–	2004 (31)	D
Iran	EN	26.7		44.6		79.2	85.1	Amoxicillin	Metronidazole	Erythromycin	–	2007 (32)	D
Iran	GP	80.6		73.1		58	74.2	Amoxicillin	Amoxicillin/metronidazole	–	–	2011 (33)	D
Iran	GP	25.1		77.2		32.9	75.3	Amoxicillin	Penicillin VK	Erythromycin	6–10	2011 (34)	D
India	GP	60.6	65.2	44.9	56.9	69.4	92.1	Amoxicillin	Amoxicillin/metronidazole	Erythromycin	5	2013 (35)	D
India	GP	37.6	71.6	38.2	59.1	46.9	90.2	Amoxicillin	Oxoflacyn/ornidazole	Erythromycin	4.3 ± 1.3	2014 (36)	D
India	GP	7.8	10.0	3.4	7.2	15.0	56.4	Amoxicillin	Oxoflacyn/ornidazole	Erythromycin	–	2014 (4)	D
Saudi Arabia	GP	27.3	42.0	23.5	59.0	46.4	77.0	Amoxicillin	Amoxicillin/metronidazole	Clindamycin	–	2015 (37)	D
Pakistan	GP	21		–	–	–	–	Amoxicillin	Amoxicillin/metronidazole	–	–	2015 (38)	D
Africa													
Yemen	GP	32		66.3		72	78	Amoxicillin	Spiramycin	Erythromycin	–	2006 (39)	D
Oceania													
Australia	GP	–	–	0	–	39	98	Amoxicillin	–	Erythromycin	–	2000 (40)	D

*Treatment duration is indicated in different forms by different investigators; (i) mean ± SD, (ii) mean (range), (iii) only mean, (iv) only range.
AB, antibiotic; D, Very Low; DS, dental surgeon; EN, endodontist; GP, general practitioner; IP, irreversible pulpitis, moderate/severe symptoms; IP-AP, irreversible pulpitis with apical periodontitis, moderate/severe symptoms; NP-AP-1, necrotic pulp with apical periodontitis, no swelling, no/mild symptoms; NP-AP-2, necrotic pulp with apical periodontitis, no swelling, moderate/severe symptoms; NP-AP-3, necrotic pulp with apical periodontitis, sinus tract present, no/mild symptoms; including chronic apical periodontitis; NP-AP-4, necrotic pulp with apical periodontitis, swelling, moderate/severe symptoms, including dentoalveolar abscess; P, prescriber; PD, paediatric dentist.

swelling (33% of dentists); and prescription of antibiotics for non-vital pulps with swelling (the largest percentage, 60.5–88.2% of dentists)[18]. Retrospectively, in 2002, the prescribing habits of active members of the American Association of Endodontists (AAE) were newly analysed, and it was concluded that most of its members were selecting the most suitable antibiotic for the treatment of orofacial infections, but still many were prescribing antibiotics inappropriately.

The antibiotic prescribing habits of paediatric dentists were also studied by analysing the surveys of 4,636 members of the American Academy of Pediatric Dentistry[19]. A trend was found toward overprescription of antibiotics for the following conditions: irreversible pulpitis, with (32%) and without (42%) vital pulp; and localised dentoalveolar abscess, with (68%) and without (39%) draining fistula.

In the United States, the most frequently prescribed antibiotic is penicillin VK, which is the first-choice antibiotic in 69% of dentists[20]. Only 28% of American endodontists prescribed amoxicillin[9]. Erythromycin[20] and clindamycin[9] were prescribed in patients allergic to penicillin.

Europe

Several surveys have studied the pattern of antibiotic prescription in the treatment of endodontic diseases amongst European dentists. In a survey carried out amongst British general dental practitioners providing National Health Service (NHS) treatment[21], more than 95% of dentists prescribed antibiotics for spreading infections; and some dentists (12.5%) prescribed antibiotics for acute pulpitis, either before (69%) or after (23%) the drainage of acute abscesses[21]. In a later study, Tulip and Palmer[22] found that 39% of dentists prescribed antibiotics for pulpitis, 44.4% when apical periodontitis was evident, 68.8% for apical periodontitis with no swelling and 84.8% for acute apical abscess. Dailey and Martin[23], studying the prescription of antibiotics in dental emergencies, concluded that in 75% of cases, antibiotics were inappropriately prescribed.

Mainjot *et al.*[24] analysed antibiotic prescribing in dental practice in Belgium. Antibiotic prescriptions were distributed as follows: in the absence of fever (92.2%); for periapical abscess (63.3%); without any local treatment (54.2%); and for pulpitis (4.3%). Among Lithuanian dentists, more than 60% of the respondents reported prescribing antibiotics for symptomatic apical periodontitis[25]. The majority of the respondents (84%) reported symptomatic apical periodontitis with periostitis as being a clear indication for the prescription of antibiotics. Approximately 2% of the respondents reported prescribing antibiotics for symptomatic pulpitis. A correlation was observed between the duration of professional activity and prescription of antibiotics. The authors concluded that Lithuanian dentists tended to overprescribe antibiotics for cases of pulpitis and apical periodontitis.

Rodríguez-Nuñez *et al.*[26] studied the prescription habits of antibiotics by Spanish endodontists. For irreversible pulpitis, 40% of respondents prescribed antibiotics. For necrotic pulp, acute apical periodontitis and no swelling, 53% of the respondents prescribed antibiotics. Almost 22% of the professionals prescribed antibiotics for necrotic pulps with chronic apical periodontitis and a sinus tract. Some endodontists were prescribing antibiotics unnecessarily to treat minor infections. Segura-Egea *et al.*[27] analysed the use of antibiotics amongst Spanish oral surgeons. Respondents prescribed antibiotics for irreversible pulpitis (86%) and for necrotic pulp, acute apical periodontitis and no swelling (71%). For necrotic pulps with chronic apical periodontitis and a sinus tract, nearly 60% of respondents prescribed antibiotics. Some oral surgeons also prescribed antibiotics inappropriately. Kaptan *et al.*[28] studied the antibiotic-prescription pattern in the treatment of dental emergencies in Turkey: 22% of dentists prescribed antibiotics for patients with acute apical periodontitis, and 41% of dentists prescribed antibiotics for patients with acute apical abscess. A high percentage of Turkish dentists (74.4%) were prescribing antibiotics unnecessarily[29]. In Croatia[30], antibiotics were prescribed in 46% of cases of pulpitis and in 80% of cases diagnosed as acute apical abscess.

Amoxicillin, alone or in combination with clavulanic acid, is the preferred prescribed antibiotic in endodontic infections in all surveys carried out in Europe[22,24,25,27,28,30]. In Belgium, 82% of all prescriptions were for amoxicillin, amoxicillin+clavulanic acid and clindamycin[24]. Among Lithuanian dentists, amoxicillin was the antibiotic most preferred during endodontic treatment, followed by amoxicillin+clavulanic acid[25]. However, an increase in the prescription of penicillin and a decrease in prescribing amoxicillin and amoxicillin+clavulanic acid regarding the increasing age of respondents was reported[29]. In Spain, amoxicillin was the first-choice antibiotic for 86% of respondents[26], followed by metronidazole+spiramycin (8%) and clindamycin (4%). In penicillin-allergic patients, clindamycin 300 mg was the first drug of choice (63%), followed by metronidazole+spiramycin (24%). Similarly, 90% of oral surgeons selected amoxicillin as the first-choice antibiotic and prescribed clindamycin 300 mg (65%) for penicillin-allergic patients[27]. Kaptan *et al.*[28], in a survey carried out in Turkey, found that 62% of dentists prescribed amoxicillin+clavulanate and 47% prescribed amoxicillin alone. Thirteen years previously, a study indicated that ampicillin was the first-choice antibiotic

prescribed by Turkish dentists[29]. In the UK, the principal antibiotic prescribed in endodontic infections for both adult and child patients was amoxicillin[21,23].

Asia

Salako *et al.*[31] analysed the pattern of antibiotic prescription for dental management in Kuwait. Amongst respondent dentists, 90% prescribed antibiotics when the patient shows evidence of systemic involvement, such as fever and gross or diffuse facial swelling. Sixty per cent reported that they would prescribe antibiotics when endodontic infection is associated with difficulty in swallowing and 50% reported that they would prescribe antibiotics when a patient shows localised fluctuant swelling without any systemic involvement.

Three studies have analysed the patterns of antibiotic prescription amongst Iranian dentists. Amongst the members of the Iranian Association of Endodontists[32], a high percentage of responders prescribed antibiotic for fever (78.2%) and diffuse swelling (85.1%), but in some instances, such as in acute pulpitis (26.7%) and chronic periapical lesions (79.2%), antibiotics were inappropriately prescribed. Amongst Iranian general practitioners, Navabizadeh *et al.*[33] found that only 29% of dentists had full knowledge of antibiotic-prescription guidelines for endodontic diseases. However, Vessal *et al.*[34] found that more than 40% of general dentists prescribed antibiotics for problems for which antibiotics were not required, according to good practice guidelines.

The pattern of antibiotics prescription in endodontic diseases in India has also been analysed by several investigators. Kumar *et al.*[35] determined the antibiotic-prescribing habits for pulpal and peri-apical pathology among dentists in Hyderabad, India. The total percentage of dentists who prescribed antibiotics for endodontic management was 68.5%. The most common indication for antibiotics was a necrotic pulp with acute apical periodontitis with swelling and moderate/severe preoperative symptoms (92.1%).

A survey carried out amongst Indian oral health-care providers[36] revealed that most prescribed antibiotics for irreversible pulpitis and acute apical periodontitis (72%) and necrotic pulp, acute apical periodontitis and no swelling (59%). The authors concluded that 92% of the oral health-care providers overprescribed antibiotics. Jayadev *et al.*[4] studied the pattern of antibiotic prescription for pulpal and periapical pathologies among Indian dentists. Of the respondents to the survey, 44% stated that they would prescribe medication for elevated body temperatures and evidence of systemic involvement, while 42.8% would prescribe medication for non-clinical factors, such as unsure diagnosis. Necrotic pulp with acute apical periodontitis with swelling present and moderate-to-severe preoperative symptoms was the most common condition identified for antibiotic therapy (56%). Fifty-five per cent of dentists would not prescribe an antibiotic and analgesic after root-canal treatment.

Iqbal[37] evaluated the pattern of antibiotic prescription of dentists for endodontic infections in northern Saudi Arabia. Amongst respondents, 77% prescribed antibiotics for necrotic pulp with acute apical periodontitis when swelling and moderate or severe preoperative symptoms were present, and 59% prescribed antibiotics when no swelling was present. In patients with irreversible pulpitis with moderate-to-severe symptoms, 27.3% of respondents stated that they would prescribe antibiotics. Tanwir *et al.*[38] recently examined the pattern of antibiotic and analgesic prescriptions per diagnosis by dentists in Karachi, Pakistan. Caries and pulpitis were the most common diagnoses (31%), for which 21% were prescribed antibiotics.

Regarding the most frequently prescribed antibiotics in Asian countries, Iranian general dental practitioners prescribed amoxicillin 500 mg capsules as the drug of choice for endodontic infections[33]. Amongst Indian dentists, the first antibiotic of choice in patients with no medical allergies is amoxicillin, followed by oxoflacyn/ornidazole[4,36] and amoxicillin+metronidazole[35]. The drug of choice in patients allergic to penicillin is erythromycin[4,35,36]. Amoxicillin, administered alone or with clavulanic acid or metronidazole, was the drug of choice in Saudi Arabia[37], and clindamycin was the first choice of drug in allergic patients. In Pakistan, amoxicillin and metronidazole were the most common antibiotics prescribed[38].

Africa

Only one study carried out in Africa has been found to fulfill the criteria for inclusion in this review. This study assessed the pattern of antibiotics prescribed by general dentists in Yemen[39]. Higher percentages of overprescription of antibiotics were found: 84% of dentists prescribed an antibiotic for patients without a clinical indication, such as pulpitis (32%), acute apical periodontitis without swelling (66.3%) and chronic apical periodontitis (72%). Amoxicillin and spiramycin were the first- and second-choice antibiotics, respectively, prescribed for endodontic diseases.

Australia

Only one study that assessed antibiotic-prescribing habits in Australia was found. Jaunay *et al.*[40] analysed the prescribing habits of South Australian general dental practitioners in different clinical situations related to periapical pathology. In patients with

localised infection, 39% of dentists prescribed an antibiotic, and 28% of dentists prescribed antibiotics for the treatment of a draining sinus. Although dentists knew the appropriate guidelines for antibiotic prescription, they had a tendency toward overprescription. The first-choice antibiotic in the management of endodontic diseases was amoxicillin. The alternative in allergic patients was erythromycin.

South America

Scarce data are available about the prescription of antibiotics by dentists in South American countries. In Brazil, a survey analysed the prescription pattern of systemic antibacterial and analgesic/anti-inflammatory medication by dentists, without reference to endodontic diseases[11]. Most of the Brazilian general dental practitioners (50.6%) prescribed amoxicillin as the drug of choice and phenoxymethylpenicillin (28%) as the second drug of choice. Erythromycin was the choice in allergic patients.

Figure 2 summarises the first-choice antibiotics worldwide in the treatment of endodontic infections in non-penicillin-allergic and penicillin-allergic patients.

DISCUSSION

One of the main findings of this review is that dentists are overprescribing antibiotics in the management of endodontic infections. A non-indicated condition for prescription of antibiotics in systemically healthy patients is localised swelling. However, in most regions for which data are available, such as North America[9,21–23,26–29], Asia[31–38], Africa[39] and Australia[40], high percentages of dentists prescribed antibiotics for this condition. It is necessary to improve worldwide prescribing habits of antibiotics in the treatment of endodontic infections. Moreover, educational initiatives must be developed to encourage the coherent and proper use of antibiotics in these conditions[21].

Another important finding is that there are scarce or no data about the antibiotic-prescription patterns of dentists in many countries[41], some with large populations (such as China, Indonesia, Brazil, Bangladesh, Russia, Japan and Mexico). In these countries, adequate surveys to determine the antibiotic-prescription pattern of dentists in the treatment of endodontic infections should be encouraged.

When there is evidence of systemic involvement and gross, rapid and diffuse spread of infection, antibiotics must be prescribed[42]. However, most chronic or even acute endodontic infections can be successfully managed by root-canal system disinfection, which eliminates the source of infection, followed by drainage of the abscess without the need for antibiotics[27]. The dental pulps of patients who have irreversible pulpitis with moderate-to-severe symptoms, with or without an acute apical

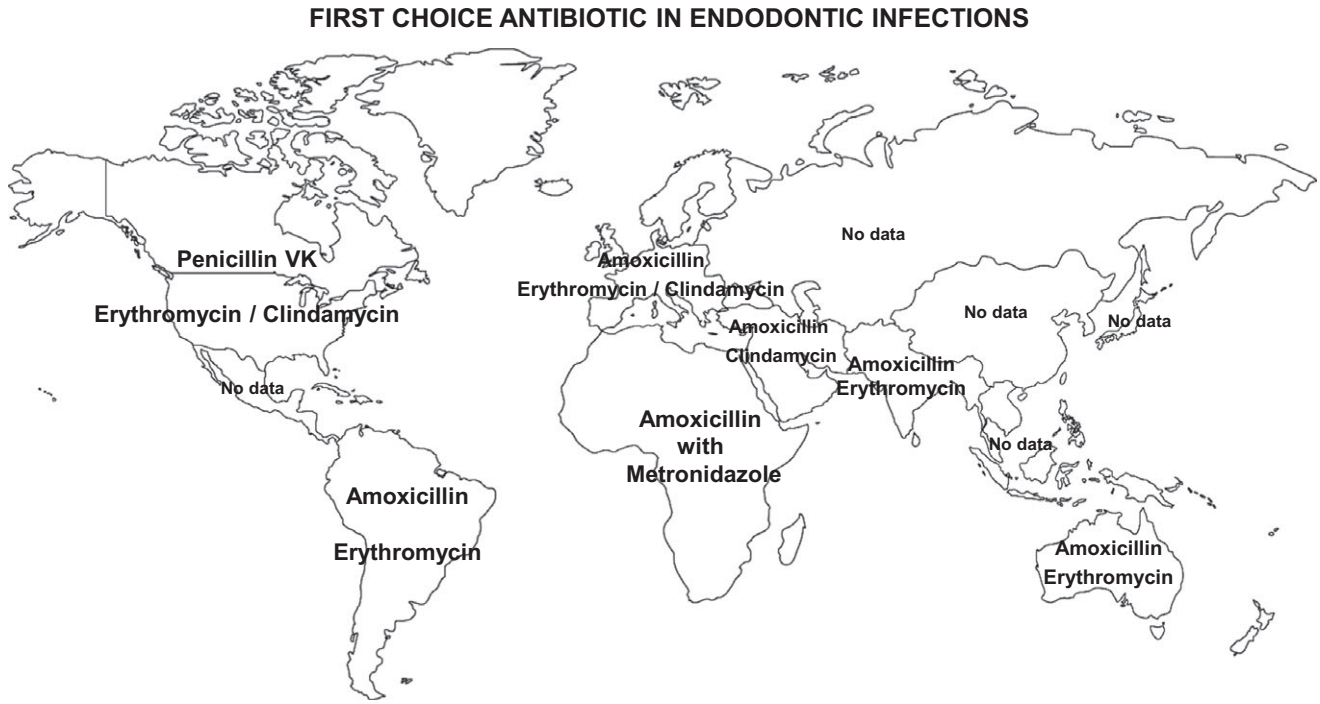

Figure 2. First-choice antibiotics used worldwide for the treatment of endodontic infections in non-penicillin-allergic and penicillin-allergic patients. Two antibiotics are given for each country; the upper one is that given to non-penicillin-allergic patients and the lower one is that given to penicillin-allergic patients. There are no data from China, Indonesia, Brazil, Bangladesh, Russia, Japan and Mexico.

periodontitis component, can still be vital[43]. These patients have no signs of systemic involvement and antibiotics are not indicated, but a high percentage of dentists still prescribed antibiotics in these situations[18,24,31,44].

A recently published systematic review analysed the evidence available on antibiotic usage for endodontic infections and pain. It was concluded that the best available clinical evidence does not support the prescription of antibiotics for treatment of endodontic diseases unless the spread of infection is systemic, the patient is febrile, or both[45]. Thus, in cases of necrotic pulp with acute or chronic apical periodontitis, with no swelling and moderate/severe symptoms, antibiotic use is not indicated. The proper treatment in these cases should be limited to endodontic treatment, with debridement of the root-canal space and analgesics. Usually, a correct diagnosis, together with effective root-canal treatment, will be sufficient to reduce the microbial load to allow healing[45]. However, in this situation, again, a high percentage of dentists prescribe antibiotics[4,17,18,27,36,38]. The mere presence of a sinus tract, in cases of asymptomatic necrotic pulp with chronic apical abscess, is not an indication for antibiotics because there is no systemic involvement[42]. The proper treatment of an uncomplicated abscesses is effective drainage and removal of the cause. Nevertheless, prescription of antibiotics for drainage of an abscess related to a tooth has increased two-fold between 1998 and 2006[1,41]. However, antibiotics would be indicated in patients with poor health or in immunocompromised patients, when the sinus tract does not disappear or the patient develops a flare up with systemic involvement[27]. It can be interpreted that systemic involvement is present in patients with necrotic pulp, acute apical periodontitis (abscess), swelling and moderate-to-severe symptoms. In such cases, root-canal treatment, incision and drainage must be complemented with antibiotics. Most dentists (87–99%) prescribe antibiotics appropriately in this situation[9,17,18,24,26,27,36,37]. Oral infections with fever, lymphadenopathy and trismus, or facial cellulitis with or without dysphagia, are serious diseases that should be treated by antibiotics because of the possibility of spread of infection via lymph and blood circulation[41].

Regarding the prescribed antibiotics, amoxicillin is the first-choice drug in the treatment of endodontic infections in most countries[4,24,26,27,31,36,37,41]. Amoxicillin represents a synthetic improvement of the original penicillin molecule, being readily absorbed when it is taken with food and resistant to damage from stomach acid[46]. Moreover, compared with penicillin, amoxicillin has broader spectrum of effectiveness against the cell wall of Gram-negative bacteria, being able to last a bit longer as a result of its resistance to stomach acid[46]. Amoxicillin+clavulanic acid, because of its broad spectrum, low incidence of resistance, pharmacokinetic profile, tolerance and dosage, is one of the antibiotics recommended for the treatment of odontogenic infections[47]. Nevertheless, the broad spectrum of amoxicillin is probably more than is required for the treatment of apical periodontitis. The AAE claim that its use in a healthy individual may contribute to the global antibiotic-resistance problem[48]. This could be the reason why, in the United States, penicillin is the first-choice antibiotic in the treatment of endodontic infections[9,17,18]. Penicillin is a narrow-spectrum antibiotic that is effective against aerobic Gram-negative cocci and anaerobes. Penicillin has two main drawbacks: its poor absorption from the intestinal tract, meaning that more than 50% of an oral dose is wasted; and its short-acting effect, with half of the amount circulating being removed every half hour[46].

Metronidazole has been suggested as a supplemental medication for amoxicillin[48] because of its excellent activity against anaerobes. In Europe and the Middle East, metronidazole is the second-choice antibiotic in the treatment of endodontic infections[27,31,37], and in Asia and Africa the combination amoxicillin+metronidazole is the first-choice drug[4,38].

When a patient is allergic to penicillins, the first drug of choice varies throughout the world. In Spain[26,27] and the United States the first drug of choice is clindamycin[9], an antibiotic active against oral anaerobes and facultative bacteria. However, high doses of clindamycin increase the probability of serious side effects, such as pseudomembranous colitis[49] and neutropenia[50]. On the other hand, in Belgium[24], the Middle East[31] and Asia[4,35] the first-choice antibiotic in penicillin-allergic patients is the macrolide erythromycin; the spectrum of activity of erythromycin against bacteria is comparable with that of penicillin[46]. In Canada, although there are no data on antibiotic-prescribing patterns in patients with endodontic disease, it has been found that antibiotics prescribed after dental treatment primarily were penicillins[13], and that erythromycin[13] was prescribed to patients allergic to penicillin.

Since the 1970s, the problem of antibiotic prescription in dentistry and, specifically in endodontics, has been analysed using surveys. The survey instrument has historically been successful in obtaining pertinent information. Specifically, some surveys have been designed to collect information relative to the patient‘s conditions for which antibiotics were prescribed and the types of antibiotics used. Nevertheless, in these surveys, the overall response rate is not particularly high, ranging from 30% to 45%[51]. Taking

into account that most of the studies included in this review are based on these types of surveys, the pattern of antibiotics prescription from each geographical area may not be well represented by the results of one or a few survey-based studies.

For several years, there have been efforts to develop new antibacterials that are effective against resistance. The concept of anticipation resistance is now emerging. Computational algorithms and experimental evolution could aid in predicting antimicrobial-resistance patterns, thus improving the design of antimicrobial drugs. Computationally predicting drug-resistance mutations early in the discovery phase would be an important breakthrough in antibiotic development.

In conclusion, amoxicillin is the drug of choice for endodontic infections in most countries, and clindamycin and erythromycin are the drugs of choice in patients allergic to penicillin. Dentists worldwide prescribe antibiotics for conditions for which they are not indicated, such as pulpitis. There is overprescription of antibiotics in the management of endodontic infections. It is therefore necessary to amend antibiotic-prescribing habits in the treatment of endodontic infections, as well as to introduce educational initiatives to encourage the coherent and proper use of antibiotics in these conditions.

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Conflict of interest

The authors deny any conflicts of interest.

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