Clinical Oral Investigations
https://doi.org/10.1007/s00784-021-03965-x

ORIGINAL ARTICLE

A meta-analysis on the efficacy of the ropivacaine infiltration in comparison with other dental anesthetics

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Received: 15 March 2021 / Accepted: 22 April 2021

Abstract

Objectives The aim of this meta-analysis was to assess the clinical efficacy and safety profile of ropivacaine in comparison with other dental anesthetics in different clinical conditions.

Materials and methods This meta-analysis was registered in the National Institute for Health Research PROSPERO (ID: CRD42020205580). PubMed and Scholar Google were consulted to identify clinical trials using ropivacaine in comparison with other local anesthetic drugs for any dental procedure. Articles comparing ropivacaine and other dental anesthetics were assessed with the Cochrane Collaboration's risk of bias tool. Data from reports without a high risk of bias were extracted (anesthetic and adverse effects) and analyzed using the Review Manager Software 5.3. for Windows and the Risk Reduction Calculator.

Results Ropivacaine produces a longer anesthetic time when compared with lidocaine/adrenaline (n = 260; p = 0.00001) and similar anesthesia than bupivacaine (n = 190).

Conclusions Data of this study indicate that ropivacaine infiltration produces a longer anesthetic time when compared with lidocaine and articaine but not when compared to bupivacaine in dental procedures.

Clinical relevance Ropivacaine was more effective than lidocaine for dental anesthesia. For this reason, the manufacture of a ropivacaine dental cartridge with a suitable concentration could be an important advancement for clinical practice.

Keywords Ropivacaine · Lidocaine · Bupivacaine · Articaine · Dental anesthesia

Introduction

A large number of dental procedures are performed under dental anesthesia daily [1]. The local anesthetics, a kind of amino amide molecule, exert its action by blocking sodium channels and preventing depolarization of nerve cells. Its adverse and secondary effects mainly affect the nervous and cardiovascular systems [2, 3]. Lidocaine, articaine, bupivacaine, mepivacaine, and prilocaine are the local anesthetics most used in dentistry [4].

Lidocaine is the most widely used local anesthetic in odontology. It has demonstrated good clinical efficacy in most dental procedures [5–8]. However, recent studies have shown that articaine is more effective than lidocaine for buccal surgery [9], as well as to carry out the inferior alveolar nerve block (IANB) in patients with irreversible pulpitis [4, 10].

Local anesthetics can be combined with a vasoconstrictor—epinephrine or norepinephrine—with the purpose of increasing the surgical work time [11]. However, this pharmacological mixture increases the possibility of adverse effects [12, 13]. The adverse reactions to local anesthetics occur by allergy or overdose mainly [13–17]. Besides, dental anesthetics could contain well-known allergens such as methylparaben and metabisulfite [15, 18]. The main adverse effects related to the local anesthetics are

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Published online: 28 April 2021

neurologic (syncope and seizure) and cardiac [19]. Fortunately, the mortality risk by using local anesthetics and vasoconstrictors is low [1].

In the 1990s, ropivacaine, an amide drug with an improved safety profile compared to other local anesthetics, was introduced to the clinical practice [20, 21]. Ropivacaine is a long-acting, amide group anesthetic, producing low toxicity on the nervous and cardiovascular systems, as well as an overall reduced systemic toxicity in comparison to bupivacaine despite the similarity of their chemical structures. This is due to a difference in the chemical structure of ropivacaine which is a pure optical S(—) enantiomer of N-n-propyl-2,6-pipecoloxylidine. This propyl group (S(—) enantiomer) provides a wider safety to ropivacaine because it makes it fat-soluble and less toxic [22–32].

In dentistry, several clinical trials comparing the clinical efficacy and safety of the infiltration of ropivacaine and other dental anesthetics have been made with results in favor and against that drug [22–40]. For this reason, the aim of this systematic review and meta-analysis was to assess the clinical efficacy and safety profile of ropivacaine in comparison with other local agents in dental anesthesia.

Material and methods

Study design

To address the study's purpose, a systematic review and meta-analysis were designed and implemented following the Cochrane Group fundamentals [41]. The study population was composed of all the publications on the topic found between the years 2000 and 2020 in electronic databases. This review was registered in the National Institute for Health Research PROSPERO (ID: CRD42020205580).

Selection criteria

Articles reporting the clinical efficacy and safety of the ropivacaine infiltration in comparison with other local agents in dental anesthesia were included. Randomized clinical trials, parallel groups, crossover, or split-mouth designs were considered.

The inclusion criteria were as follows (PICO) [41, 42]:

Population: Randomized, double-blind, parallel-groups, or crossover clinical trials comparing the anesthetic activity of ropivacaine and other dental anesthetics.
Interventions: Local infiltration of ropivacaine.
Control: Comparing with lidocaine, articaine, mepivacaine, or bupivacaine.
Outcome: Onset of lip anesthesia, the onset of pulpal anesthesia, duration of lip anesthesia, duration of pulpal anesthesia, consumption of the first analgesic medication in a 24 h period after third molar surgery, patients with postoperative pain following the surgical removal of a third molar, and adverse effects.

Exclusion criteria:
Clinical studies with a loss to follow-up more than 20%.

Electronic search

PubMed and Scholar Google bibliographic databases were consulted with the purpose of identifying clinical trials (journal articles or published-ending-thesis) using ropivacaine in comparison with other local anesthetic drugs for any dental procedure. The word "ropivacaine" was used in PubMed and Scholar Google with the next keywords: "Bupivacaine", "Lidocaine", "Mepivacaine", "Articaine", "Pulpal anesthesia", "Lip anesthesia", "Third molar surgery", "Oral surgery", "Third molar extraction", "Endodontics", "Root canal treatment", "Periodontal surgery", "Surgical periodontal treatment", and "Dental anesthesia". These words were combined in PubMed with the next filters: "Clinical trial", "Controlled clinical trial", "Clinical study", and "Journal article" in the article type section and "English", "Portuguese", and "Spanish" in the Language option. Thereafter, three blinding independent evaluators read the abstracts and gave their opinions to consider them or not in the full-text evaluation [43–45].

Assessment of bias

The quality of studies was assessed using the Cochrane Collaboration's risk of bias tool for examining 7 points: (1) random sequence generation, (2) allocation concealment, (3) masking (blinding of participants and personnel), (4) blinding outcome assessment, (5) incomplete outcome data, (6) reporting bias, and (7) other bias [5, 41–45]. The clinical trials without a high risk of bias in any of these seven points were judged of high quality. Some authors were contacted by email to clarify doubts about the methodology used or to request their support by sending data such as means and standard deviation when medians and ranges or graphs were reported in the article. The quality evaluation of the articles was done by three blinded independent evaluators [43–45].

Data extraction

The means and standard deviations, or frequencies of the indicators of clinical efficacy, were obtained from trials with a low/moderate risk of bias. Those variables were the following: author, design study, treatment groups, size sample (*n*), dose, the onset of lip anesthesia, the onset of pulpal anesthesia, duration of lip anesthesia, duration of pulpal anesthesia, consumption of the first analgesic medication within 24 h after

third molar removal, number of patients with postoperative pain in third molar surgery, and adverse effects.

Statistical analysis

For the evaluation of numerical data, the inverse variance statistical method and mean difference were used. To assess the dichotomous variables, the Mantel-Haenszel statistical technique and effect measure by odd ratio (OR) were employed. All meta-analyses were done using a random effect model with the Review Manager Software 5.3. for Windows. The I^2 was employed to classify the inconsistency: an I^2 value from 0 to 30% = unimportant inconsistency, an I^2 value from 31 to 70% = moderate inconsistency, whereas an I^2 value from 71 to 100% = considerable inconsistency. A p value overall test < 0.05 and an OR (> 1 and within the 95% confidence intervals (CIs)) was considered a statistical difference [41, 46–49].

The absolute risk reduction (ARR), the number needed to treat (NNT), and 95% CIs were calculated for the consumption of the first analgesic in 24 h after third molar surgery and patients with postoperative pain following the surgical removal of a third molar using the Risk Reduction Calculator [50] when a meta-analysis showed a $p < 0.05$.

Results

Electronic search

The digital strategies used in PubMed and Scholar Google identified a total of 1358 reports published to June 2020. After reviewing the abstract, 19 clinical trials were considered for full-text assessment [22–40]. Only 14 (73.68%) full-text studies met the quality criteria according to the Cochrane Collaboration's risk of bias tool [23, 24, 26, 27, 29–31, 34–40]. Figure 1 shows a flowchart of the number of identified, included, excluded, and assessed articles.

Assessment of bias and clinical efficacy qualitative analysis

A low level of bias was shown for 12 journal articles [23, 24, 26, 27, 29–31, 34–40], and 2 theses according to the Cochrane Collaboration's risk of bias tool (Fig. 2). According to the author's conclusion of each article from Table 1, ropivacaine was better than other dental anesthetics in 10 (71.42%) of the 14 clinical trials. In the same manner, three clinical trials show similar clinical effectiveness between ropivacaine and other drugs, and one article informed that lidocaine/adrenaline was better than ropivacaine for intraligamentary anesthesia. The most important features of the 14 adequate quality reports are presented in Table 1 [23, 24, 26, 27, 29–31, 34–40, 51, 52].

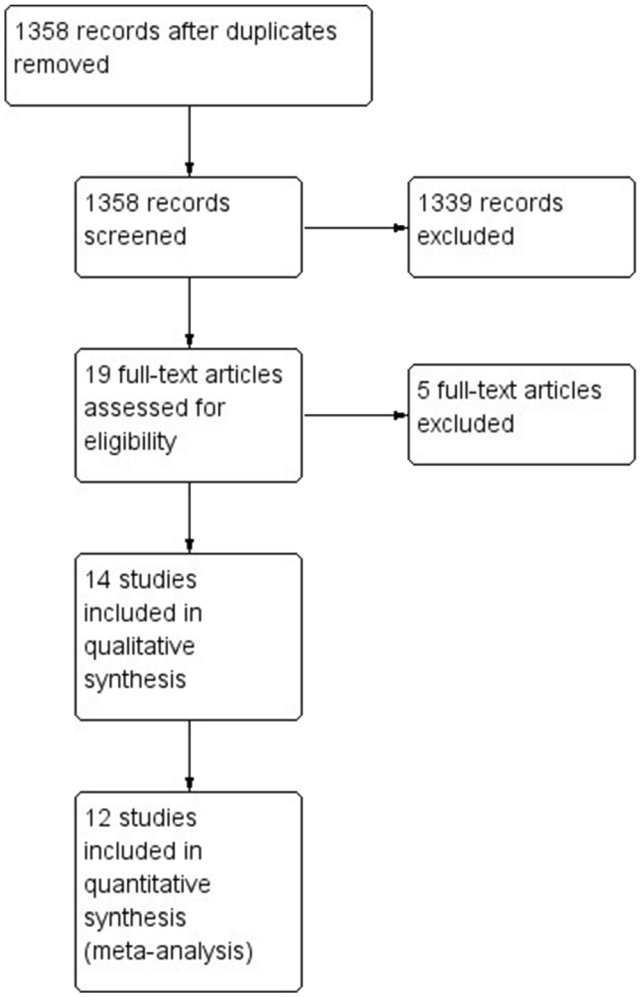

Fig. 1 Study flow chart

Onset of lip anesthesia

The evaluation of the onset of lip anesthesia was made with the results of 7 scientific articles [23, 31, 35–40, 51]. The pooled analysis was done with the data of 430 patients. The data showed that lidocaine/adrenaline produces a faster onset compared to ropivacaine ($Z = 3.14$; $p = 0.0001$; mean difference = 1.36; CIs = 0.51 to 2.21; Fig. 3), and this last drug acts faster than bupivacaine/adrenaline ($Z = 2.28$; $p = 0.02$; mean difference = − 0.70; CIs = − 1.30 to − 0.10; Fig. 3), and articaine/adrenaline ($Z = 5.56$; $p = 0.00001$; mean difference = − 1.88; CIs = − 2.54 to − 1.22; Fig. 3).

Onset of pulpal anesthesia

Only 2 clinical trials [29, 51] reported the onset of pulpal anesthesia of ropivacaine and lidocaine/adrenaline or bupivacaine in the anterior area of the upper jaw (lateral incisor and canine), with a total of 140 patients. However, the test for overall effect has shown no statistical

Table 1 Details of included clinical trials

First author, study design and, kind of document	Treatments (*n*)	Patients, surgical procedure, and postoperative analgesic	Evaluation of the clinical efficacy	Adverse effects	Conclusion
Brković et al. (2008) [23]. Randomized, double-blind, parallel, clinical trial. Journal.	Group A: 0.75% ropivacaine without vasoconstrictor (*n* = 10) Group B: 5% bupivacaine (*n* = 10)	Healthy patients (ASA I). Third molar surgery. Ibuprofen tablets of 400 mg.	Onset and duration of anesthesia, pain during and after surgery, and postoperative analgesic consumption.	Not assessed	Similar anesthetic action was observed between ropivacaine and bupivacaine.
Brković et al., (2017) [24]. Randomized, double-blind, parallel, clinical trial. Journal.	Group A: 2% lidocaine/1:80,000 epinephrine plus saline (*n* = 22). Group B: 1 % ropivacaine plus saline (*n* = 20). Group C: 2% lidocaine/adrenaline plus ropivacaine (*n* = 22).	Healthy patients (ASA I). Third molar surgery. Ibuprofen tablets of 400 mg.	Onset and duration of anesthesia, pain during and after surgery, and postoperative analgesic consumption.	Not evaluated	Ropivacaine was better than lidocaine/adrenaline, with better anesthesia and analgesia in third molar surgery.
Carvalho-Pontes et al., (2011) [26]. Randomized, double-blind, crossover, clinical trial. Journal.	Group A: Ropivacaine 7.5 mg/mL without vasoconstrictor (*n* = 17). Group B: 2% lidocaine and 1:100,000 adrenaline (*n* = 17).	Healthy patients (ASA I-III). Third molar surgery. Diclofenac 50 mg and Paracetamol 500 mg.	Onset and duration of anesthesia, pain after surgical procedure and adverse effects.	Not reported	Ropivacaine is a good alternative for third molar surgery, with a longer anesthetic action time and better analgesia in the immediate postoperative period than lidocaine/adrenaline.
Crincoli et al., (2015) [27]. Randomized, double-blind, crossover, clinical trial. Journal.	Group A: Mepivacaine alone (30 mg/mL) was used for the alveolar nerve block, while mepivacaine/adrenaline (20 mg/mL and 1:80000) was used to anesthetize the buccal soft tissues (*n* = 45). Group B: Ropivacaine alone was used for the alveolar nerve block and soft tissue anesthesia (7.5 mg/mL) (*n* = 45).	Healthy patients without systemic diseases. Third molar surgery. Ibuprofen 600 mg.	Clinical effectiveness of anesthetic agents, pain after surgery, rescue analgesia and adverse effects.	Not reported	Ropivacaine produced a delayed onset of postoperative pain, prolonged lip numbness, reduced pain score at 1 and 2 hours after surgery, and similar safety profile, compared with mepivacaine/adrenaline.
Franz-Montan et al., (2012) [29]. Randomized, double-blind, crossover, clinical trial. Journal.	Group A: 0.5% ropivacaine without vasoconstrictor (*n* = 40). Group B: 0.5% ropivacaine with 1:200,000 adrenaline (*n* = 40). Group C: Liposome-encapsulated 0.5% ropivacaine (*n* = 40). Gropu D: 2% lidocaine with 1:100,000 adrenaline (*n* = 40).	Healthy patients (ASA I). Maxillary dental anesthesia. Any analgesic was not used.	Soft tissue-and pulpal anesthesia were evaluated.	Not evaluated. Not assessed.	According to the data provided by the main author, ropivacaine with or without adrenaline is more effective than lidocaine/adrenaline.

Table 1 (continued)

First author, study design and, kind of document	Treatments (*n*)	Patients, surgical procedure, and postoperative analgesic	Evaluation of the clinical efficacy	Adverse effects	Conclusion
Kennedy et al., (2001) [30]. Randomized, double-blind, crossover, clinical trial. Journal.	Group A: 0.5% ropivacaine plain (*n* = 40). Group B: 0.5% ropivacaine with 1:200,000 adrenaline (*n* = 40). Group C: 0.5% bupivacaine with 1:200,000 adrenaline (*n* = 40).	Patients with good health. Maxillary dental anesthesia. Any analgesic was not used.	Soft tissue-and pulpal anesthesia were evaluated.		Anesthetic effects same were observed between ropivacaine/adrenaline and bupivacaine/-adrenaline
Krzeminski et al., (2011) [31]. Randomized, double-blind, parallel, clinical trial. Journal.	Group A: 4% articaine and 1:100,000 adrenaline (1.8 mL) (*n* = 30). Group B: 1.8 mL 0.5% plain ropivacaine (*n* = 30).	Healthy patients without systemic diseases. Maxillary dental anesthesia. Any analgesic was not used.	Anesthesia (soft tissue and dental pulp) and adverse reactions were evaluated.	Ropivacaine increased the diastolic blood pressure (mmHg) and heart rate (beats per minute), compared with the group A, but these fluctuations were not considered clinically important.	Ropivacaine showed a shorter onset time of the local anesthesia and longer time duration of soft tissue and pulp anesthesia, in comparison with articaine.
Meechan et al., (2002) [34]. Randomized, double-blind, crossover, clinical trial. Journal.	Group A: 2% lidocaine with 1:80,000 epinephrine (*n* = 24). Group B: 0.75% ropivacaine (*n* = 24). Group C: 1% ropivacaine (*n* = 24).	Healthy patients (ASA I). Intraligamentary anesthesia. Any analgesic was not used.	Soft tissue-and pulpal anesthesia, and adverse reaction were evaluated.	Different adverse effects were reported by using both drugs.	Lidocaine/adrenaline was better than ropivacaine for intraligamentary anesthesia
Mishra et al., (2020) [40]. Randomized, double-blind, parallel, clinical trial. Journal.	Group A: 2% lidocaine/1:80,000 adrenaline (*n* = 20). Group B: 0.5 Ropivacaine without vasoconstrictor (*n* = 20).	Healthy patients Periodontal surgery Ibuprofen 400 mg and paracetamol 325 mg)			Ropivacaine produced a longer time of anesthetic activity, better postoperative analgesia, and decreased of blood loss when compared to lidocaine/adrenaline.
Ranjan et al., (2018) [35]. Randomized, double-blind, crossover, clinical trial. Journal.	Group A: 2% lidocaine/1:200,000 adrenaline (*n* = 20). Group B: 0.75% ropivacaine (*n* = 20).	Patients without systemic diseases. Third molar extraction.	Onset and duration of anesthesia, pain during surgery.	Not assessed	Ropivacaine was not superior than lidocaine/adrenaline for pterygomandibular nerve block.
Reddy et al., (2019) [36]. Randomized, double-blind, crossover, clinical trial.	Group A: 0.75% ropivacaine without vasoconstrictor (*n* = 60). Group B: 2% lidocaine/1:80,000 adrenaline (*n* = 60).	Healthy patients (ASA I). Third molar surgery. Ibuprofen tablets of 400 mg.	Onset and duration of anesthesia, pain during and after surgery, and postoperative analgesic consumption.	Not evaluated.	Ropivacaine was superior than lidocaine/adrenaline, showing better anesthesia, analgesia and safety profile in third molar extraction

Table 1 (continued)

First author, study design and, kind of document	Treatments (*n*)	Patients, surgical procedure, and postoperative analgesic	Evaluation of the clinical efficacy	Adverse effects	Conclusion
Journal.					
Rodrigues-Palma et al., (2005) [51]. Randomized, double-blind, crossover, clinical trial. Thesis.	Group A: 0.5% bupivacaine and 1:200,000 adrenaline (*n* = 30). Group B: 1% ropivacaine/1:200,000 adrenaline (*n* = 30).	Healthy patients (ASA I). Third molar surgery. Paracetamol tablets of 750 mg	Onset and duration of anesthesia, pain after surgery.	Not evaluated.	Ropivacaine produced a shorter latency time, similar anesthetic duration and similar postoperative pain control than bupivacaine. Ropivacaine can be a reliable substitute for bupivacaine in third molar surgery.
Santos-Cunha et al., (2017) [52]. Randomized, double-blind, crossover, clinical trial. Thesis.	Group A: 2% lidocaine and 1:100,000 adrenaline (*n* = 15). Group B: 0.75% ropivacaine (*n* = 16).	Healthy patients (ASA I). Third molar surgery.	Duration of anesthesia, pain after surgery, and postoperative analgesic consumption.	Not assessed.	Ropivacaine generated more comfort, and lower consumption of NSAIDs than lidocaine with adrenaline/adrenaline.
Tijanic and Buric, (2019) [39]. Randomized, double-blind, parallel, clinical trial. Journal.	Group A: 0.75% ropivacaine without vasoconstrictor (*n* = 30). Group B: 0.5% bupivacaine (*n* = 30). Group C: 2% lidocaine/1:100,000 adrenaline (*n* = 30).	Healthy patients (ASA I). Third molar surgery. Ibuprofen tablets of 400 mg.	Onset and duration of anesthesia, pain during and after surgery, postoperative analgesic consumption and adverse reaction were assessed.	Alterations in arterial pulse were observed using lidocaine and ropivacaine.	Ropivacaine produced better anesthesia and analgesia during and after a third molar surgery than bupivacaine and lidocaine/adrenaline.

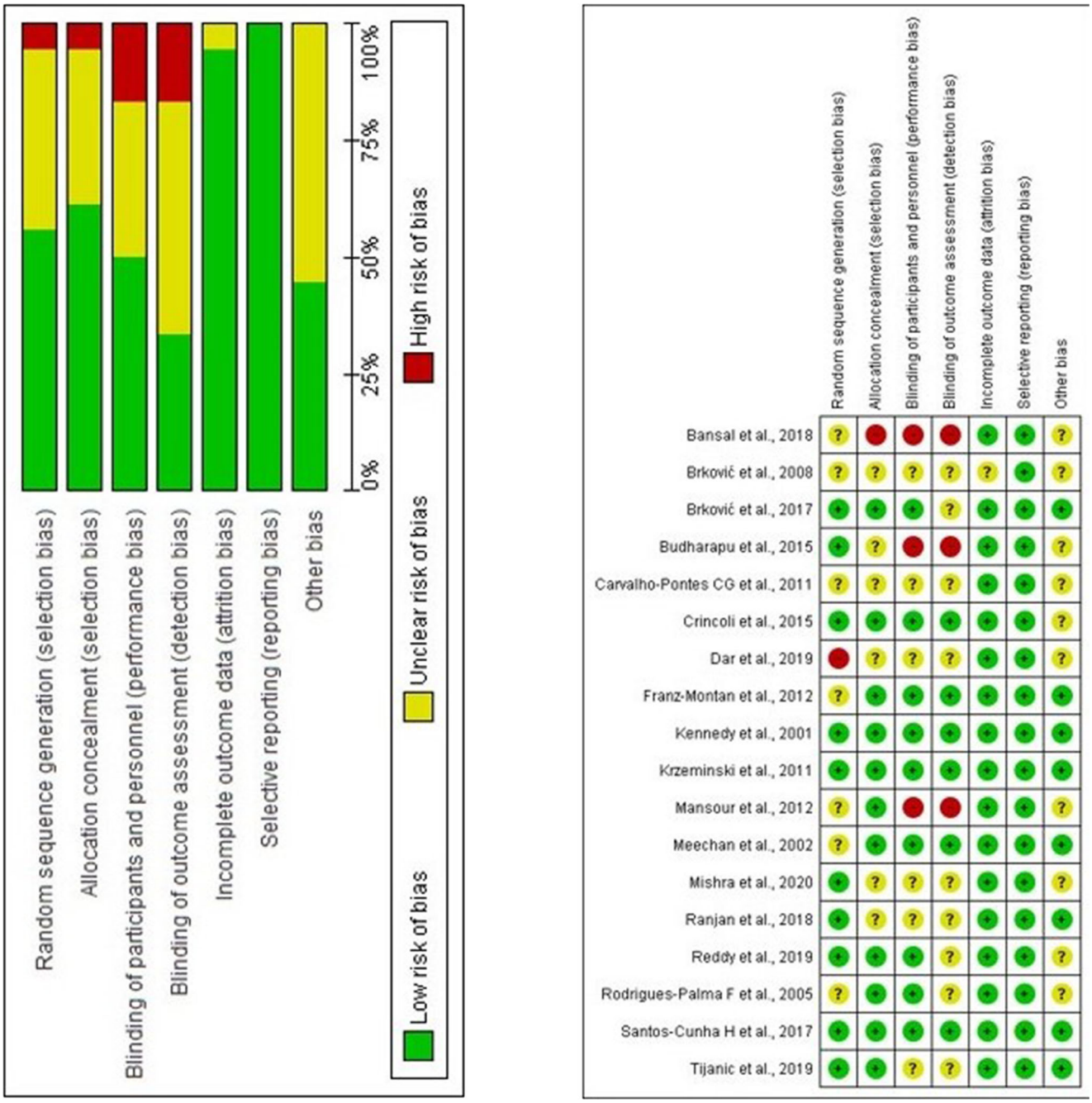

Fig. 2 Evaluation of bias risk and quality of the clinical studies

difference (Z = 1.45; p = 0.15; mean difference = 0.56; CIs = 0.20 to 1.13).

On the other hand, assessment of the onset of pulpal anesthesia of ropivacaine and lidocaine/adrenaline or bupivacaine in the posterior area (first premolar) of the inferior jaw included 2 studies [29, 51]. Test for overall effect showed a statistical difference in favor of lidocaine (Z = 2.13; p = 0.03; mean difference = 0.74; CIs = 0.06 to 1.42).

Duration of lip anesthesia

The soft tissue anesthesia was evaluated using 11 clinical trials (n = 648) [23, 24, 29–31, 35–40, 51, 52]. According to the data of these studies, ropivacaine produces a longer anesthetic time when compared with lidocaine/adrenaline (Z = 4.55; p = 0.00001; mean difference = 2.93; CIs = 1.66 to 4.19; Fig. 4) or articaine (Z = 2.93; p = 0.003; mean difference = 1.15; CIs = 0.38 to 1.92; Fig. 4), but not in comparison to bupivacaine (Z

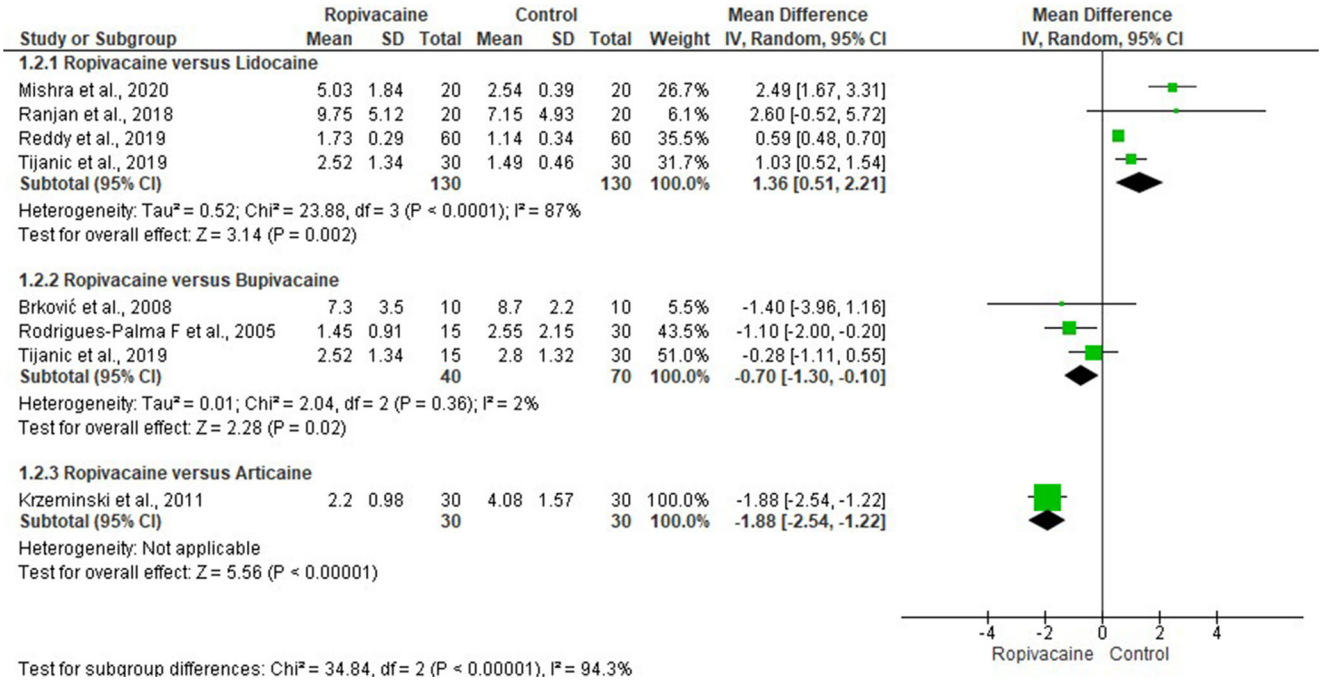

Fig. 3 Forest plot of the onset of labial anesthesia

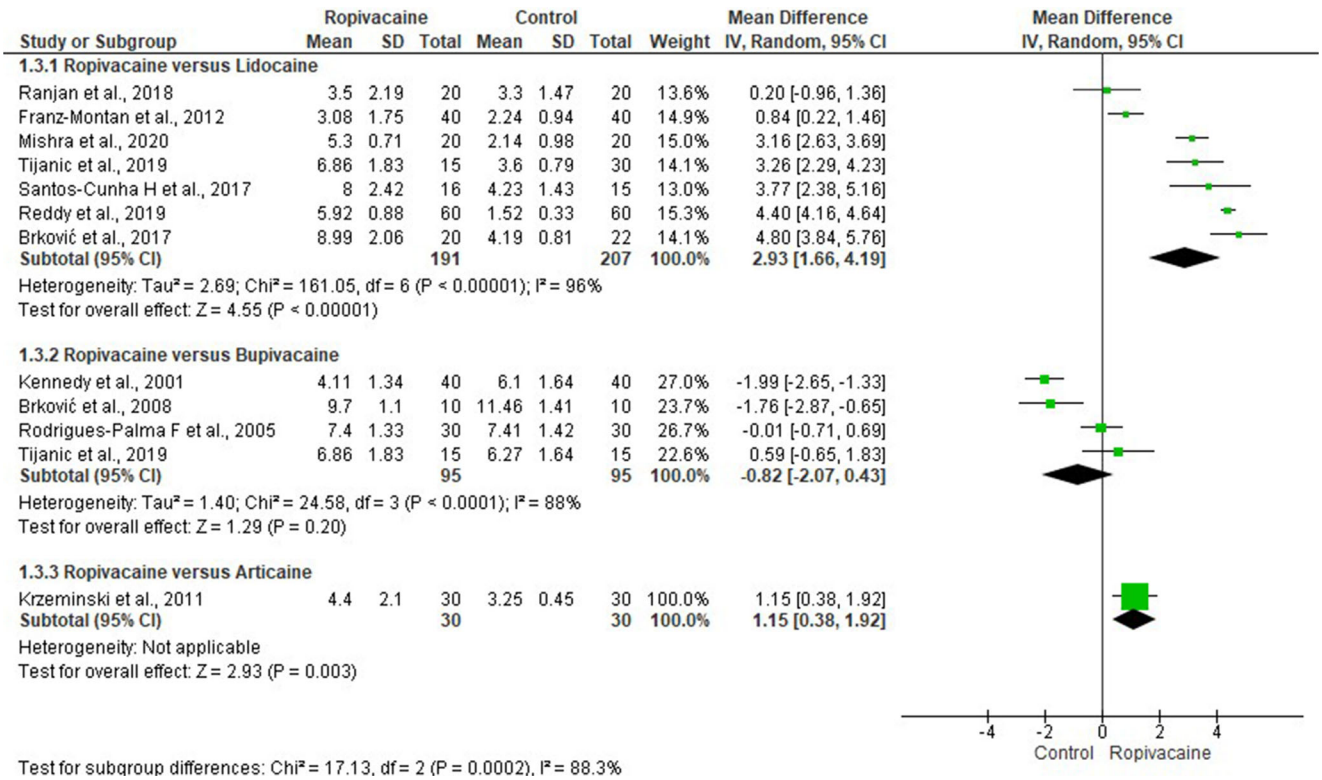

Fig. 4 Forest plot of the duration of labial anesthesia

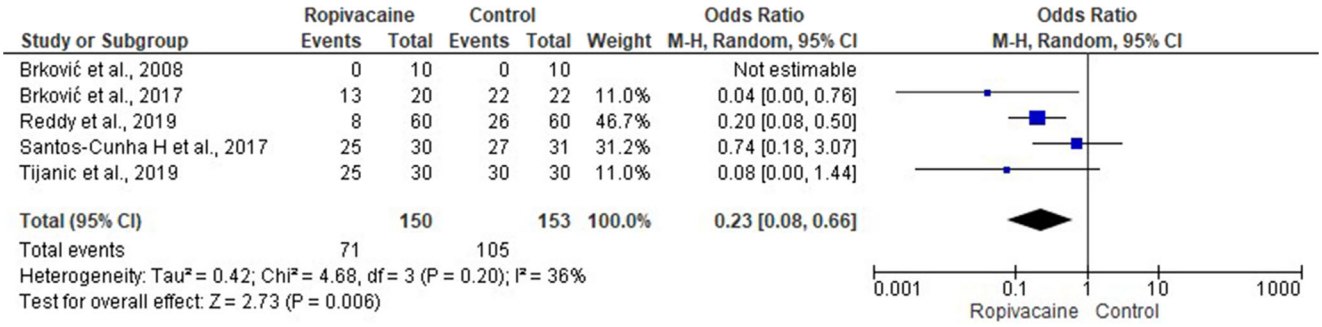

Fig. 5 Consumption of the first analgesic medication in a 24 h period after third molar surgery

= 1.29; p = 0.20; mean difference = − 082; CIs = − 2.07 to 0.43; Fig. 4).

Analgesia

The need for the first analgesic within 24 h after third molar surgery was assessed using data from 5 studies (n = 303) [23, 24, 36, 39, 52]. The overall test shows a difference in favor of ropivacaine when compared to bupivacaine ($p < 0.05$; Fig. 5). The ARR shows that 21.29% (95% CIs 10.44–32.15%) of patients will not need the first analgesic in 24 h in comparison with other anesthetics. Moreover, the NNT indicates that it should be treated 4.7 (95% CIs 3.1–9.6) patients with ropivacaine to avoid 1 patient who does not need analgesics in the first 24 h after a third molar surgery which would have happened with control.

The number of patients with postoperative pain was minor for ropivacaine compared with other local anesthetics agents (n = 124; $p < 0.05$; Fig. 6) [23, 24, 52]. The ARR indicates that 21.99% (95% CIs 6.05–37.92%) of patients will not present postoperative pain that would have been present with other local anesthetic solutions. The NNT shows that must treat 4.5 (95% CIs 2.6–16.5) patients with ropivacaine to prevent 1 postoperative pain patient that would have happened under other local anesthetic agents.

Adverse effects

The assessment of adverse reactions after the administration of drugs was done with 5 studies (n = 292). However, only Meechan et al. (2002) reported the number of patients with adverse effects for ropivacaine (n = 5/24) and lidocaine/adrenaline (n = 12/24) [34]. Tijanic and Buric (2019) informed that both ropivacaine and lidocaine/adrenaline produced modification to the hemodynamic parameters without considering adverse effects [39]. Krzeminski et al. (2011) showed that ropivacaine increased the diastolic blood pressure (mmHg) and heart rate (beats per minute), compared with the articaine, but these fluctuations were not considered clinically important [31]. Carvalho-Pontes et al. (2011) and Crincoli et al. (2015) reported no adverse reactions [26, 27].

Discussion

The most important qualitative finding of this systematic review and meta-analysis was that 10 of the 14 studies were in favor of ropivacaine according to the authors' conclusions [24, 26, 27, 29, 31, 36–40, 51, 52]. On the other hand, lidocaine had a faster onset of anesthetic effect compared to ropivacaine. However, we consider that this does not represent a difference of clinical importance (1.36 s approximately). Ropivacaine had a faster onset of anesthetic activity in comparison to articaine (1.88 s approximately), and similar to bupivacaine. The anesthetic time of ropivacaine was superior when compared with lidocaine (2.93 h) [24, 29, 35–40, 52] or versus articaine (1.15 h) [31]. This was the most important quantitative result of this study. Furthermore, the comparison between ropivacaine and bupivacaine showed no statistical difference.

Furthermore, other clinical efficacy indicators evaluated quantitatively showed a favorable trend to ropivacaine, even

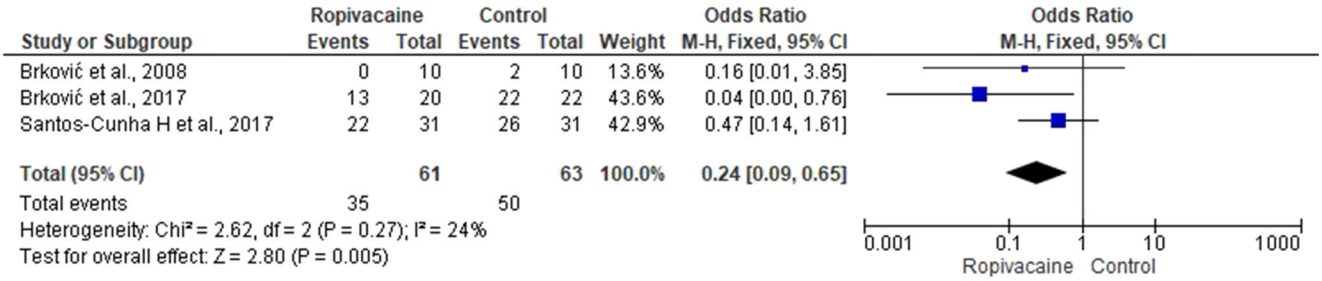

Fig. 6 Number of patients with postoperative pain following the surgical removal of a third molar

with a statistical difference according to the *p* value (onset of the pulpal anesthesia of the posterior jaw area, the consumption of the first analgesic in 24 h after third molar surgery and patients with postoperative pain following the surgical removal of a third molar).

The anesthetic effect of ropivacaine has both advantages and disadvantages. The main advantages would be the delay in the perception of a painful stimulus which helps in postoperative pain management, and it reduces the consumption of analgesics, resulting in fewer adverse effects and/or low toxicity [23, 24, 51, 52]. On the other hand, the disadvantage would be that a long-lasting anesthetic activity could cause patients to bite their lip, tongue, cheek, etc. [23, 24, 51, 52]. Therefore, we do not recommend the use of ropivacaine for pediatric or mentally disabled patients.

The anesthetic time of ropivacaine could be excessive for most general dental procedures, periodontal and oral surgery. However, if the concentration of ropivacaine could be decreased, maybe its anesthetic time could be shorted. High-quality dental anesthesia reduces fear, anxiety, suffering, and relaxes the patient, resulting in a good experience for both patient and clinician. A ropivacaine dental cartridge with the used concentrations in the clinical trials of this review would provide a high-quality alternative to bupivacaine to carry out major maxillofacial surgeries as orthognathic surgery, maxillofacial trauma reduction, and cancer surgery, etc. [53, 54].

It is very important to note that the anesthetic activity of ropivacaine was obtained without using adrenaline or any other vasoconstrictor [23, 24, 26, 27, 29–31, 34–40, 52] which has great relevance for the clinical practice because the probability of adverse effects using a vasoconstrictor could be avoided. Due to the lack of reports of adverse effects in the clinical trials of this review, the quantitative evaluation was not possible. The main adverse reactions of the local anesthetics are neurologic (syncope and seizure) and cardiac mainly [19], with a 0.000002% mortality risk after an infiltration [1]. Moreover, according to the current evidence, lidocaine seems to produce neurotoxicity, especially in diabetic, hypertensive, and smoking patients [55]. Furthermore, some systematic reviews and meta-analyses have demonstrated that lidocaine produces a chondrotoxic activity [56] and transient neurologic symptoms after spinal anesthesia [57–59]. Ropivacaine could be a good anesthetic alternative for patients.

The advantages of this review are (1) a rigorous methodology, (2) information from studies with a low/moderate risk of bias, and (3) adequate statistical management. The limitations of the present meta-analysis are mainly associated with (1) heterogeneity, (2) lack of adherence to the CONSORT recommendations [60–62], (3) the different indicators of clinical efficacy evaluated, and (4) the different scales and units of measurement used.

In conclusion, ropivacaine was better than bupivacaine and articaine, but not when compared to lidocaine about the onset of lip anesthesia. The pulpal anesthetic activity in the anterior area of the upper jaw of ropivacaine was similar to that of the other drugs. Of note, the pulpal anesthetic action in the lidocaine was better than ropivacaine on the premolar teeth. Moreover, ropivacaine infiltration produces a longer anesthetic time when compared with lidocaine and articaine but not when compared to bupivacaine in dental procedures. In the same way, ropivacaine shows a better analgesic effect when compared to other anesthetic agents. Unfortunately, a meta-analysis could not be performed comparing the adverse effects of ropivacaine compared to other dental anesthetics.

Author contribution MAIE conceived and designed the study and analyzed the results. NPFF, YAHM, and MAIE carried out the literature search and assessment of bias. MAIE and AJAC supported the statistical analysis and interpretation of results. All authors revised and approved the final version or the manuscript to be submitted.

Funding This work was supported by the CUALTOS-UDG (grant number PROSNI 2020 – Mario Alberto Isiordia-Espinoza).

Declarations

Ethical approval Not required. This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent For this type of study, formal consent is not required.

Conflict of interest The authors declare no competing interests.

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