OPEN ACCESS

Saudi Journal of Oral and Dental Research
Abbreviated Key Title: Saudi J Oral Dent Res
ISSN 2518-1300 (Print) | ISSN 2518-1297 (Online)
Scholars Middle East Publishers, Dubai, United Arab Emirates
Journal homepage: https://saudijournals.com

Original Research Article **Dentistry**

Comprehensive Survey on the Performance of Lignocaine in Root Canal Treatment

Uzmaa Shaikh[1*], Kalyani Thakre[1], Gayatri Jagtap[1], Bhagyashree Jadhav[1], Dr. Vaidehi Kulkarni[2], Dr. Hussain Mookhtiar[3], Dr. Vivek Hegde[4]

[1]Undergraduate Student, Department of Conservative Dentistry and Endodontics M.A. Rangoonwala College of Dental Sciences and Research Centre Pune
[2]Senior Lecturer, Department of Conservative Dentistry and Endodontics M. A. Rangoonwala College of Dental Sciences and Research Centre Pune
[3]Assistant Professor, Department of Conservative Dentistry and Endodontics M. A. Rangoonwala College of Dental Sciences and Research Centre Pune
[4]Professor and Head of Department of Conservative Dentistry and Endodontics M. A. Rangoonwala College of Dental Sciences and Research Centre Pune

DOI: https://doi.org/10.36348/sjodr.2024.v09i09.004 | **Received:** 16.07.2024 | **Accepted:** 24.08.2024 | **Published:** 18.09.2024

***Corresponding author:** Uzmaa Shaikh
Undergraduate Student, Department of Conservative Dentistry and Endodontics M.A. Rangoonwala College of Dental Sciences and Research Centre Pune

Abstract

Objective*:** The study aimed to evaluate the efficacy of lignocaine as a local anesthetic in root canal treatment, particularly focusing on its use in lower teeth, different administration techniques, and its performance in patients with specific challenges such as inflammation or allergy. ***Methods: A survey-based approach was utilized to gather data from clinicians on their experiences with lignocaine in endodontic procedures. The study assessed the success rates of various techniques, including the inferior alveolar nerve block (IANB), intraligamentary, and intraosseous injections. The impact of different adrenaline ratios (1:100,000, 1:80,000, and 1:200,000) on anesthesia duration and effectiveness was also analyzed. ***Results***: Lignocaine with 1:100,000 adrenaline was effective in the majority of cases, with IANB being the primary technique used for lower Lignocaine was identified as the anesthetic of choice by the majority of participants, preferred for its rapid onset and adequate duration of action. Most clinicians reported that lignocaine provided effective anesthesia for routine root canal procedures when inflammation was present or additional duration was required, clinicians recommended using supplemental techniques such as intraligamentary and intraosseous. Alternative anesthetics like articaine and bupivacaine were used successfully in patients with lignocaine allergies. ***Conclusion*:** Lignocaine remains a reliable anesthetic for root canal treatments, particularly in the lower jaw, when used with appropriate techniques and adrenaline ratios. However, challenges such as inflamed tissues and patient allergies require alternative strategies, including supplemental injection techniques and the use of different anesthetic agents. Clinicians should be adaptable in their approach to ensure effective anesthesia and patient safety. The study aimed to evaluate the efficacy of lignocaine as a local anesthetic in root canal treatment, particularly focusing on its use in lower teeth, different administration techniques, and its performance in patients with specific challenges such as inflammation or allergy.

Keywords: Lignocaine, allergy, endodontic procedures, intraligamentary.

INTRODUCTION

The association of pain with endodontic treatment is a significant source of fear for many patients and may prevent them from seeking treatment [1]. Postoperative pain management is a challenge for many physicians [2]. Local anesthetics can provide adequate pain relief in most dental surgeries, but they are often unsuccessful. These may be the result of anatomic, pharmacologic, pharmaceutical, pathologic, psychotechnical, or iatrogenic factors [3–7]. Good anesthetic techniques can eliminate pain during treatment, but pain after endodontic treatment is still a serious problem [8]. Postoperative pain management is usually managed with the use of short-term local

anesthetics and oral analgesics. Theoretically, pain control can be improved with long-term use of local anesthetics [9-12]. Lidocaine was the first commercial amide local anesthetic and is still the most widely used anesthetic in some countries [13]. It is considered a new local anesthetic [14]. And severe pain or discomfort during pulp tissue removal. In general, direct injection of LA into the vacuum provides a complete solution for tissue and root canal removal. The most important thing in the success of IPI is that its management is carried out judiciously. After pulp deroofing surgery, IPI is further injected into the root canal in a sufficient volume to facilitate the removal of all residual material from the root canal. Sodium hypochlorite (NaOCl) (range 0.5% to 5.25%) is widely used in post-IPI cleaning and treatment procedures and is considered the gold standard irrigant for soluble tissues in endodontics.

The success rate of achieving deep pulpal anesthesia in IP patients is low. The success rate of IANB can be reduced to <30% (15) and the success rate of palatal NB to <60% (22 It is generally believed that anesthesia is more difficult in patients with IP than in healthy tissues (16). Inflamed dentition exhibits a low pH, which reduces the penetration of alkaline anesthetics into the brain, thus delaying or preventing pulpal anesthesia [17]. This condition of the tooth is often referred to as "hot pulp" and requires a complete procedure to ensure the absence of pain [18, 19]. However, the effects of different anesthesia and procedures with or without additional intervention should be evaluatedold standard irrigant for pulp tissue dissolution in endodontics [20].

The success rate of achieving deep pulpal anesthesia is lower in patients with IP. The success rate of IANB can be reduced to <30% [21], and that of maxillary NBs to <60% [22]. It is broadly accepted that achieving anesthesia in patients with IP is more complex, as compared to normal, healthy pulps [23]. Inflamed pulp shows lower pH levels, lowering the penetration of basic anesthetic into the nerve membrane, thus delaying or preventing pulpal anesthesia [24]. This state of the tooth is frequently referred to as a ‘hot pulp’, which requires supplementary approaches to ensure a pain-free treatment [25]. Nonetheless, the effect of different anesthetic agents and techniques along with or without supplemental infiltration needs to be assessed.

The study aimed to evaluate 2% lignocaine hydrochloride for endodontic therapy.

MATERIALS AND METHOD

This study utilizes a cross-sectional survey design, employing a structured questionnaire of 29 questions to gather quantitative data from dental professionals regarding their experiences and opinions on the efficacy of lignocaine in root canal treatments.

The target population for this survey includes licensed dental professionals, such as Endodontists and general dentists, who perform root canal treatments. Dentists not using lignocaine and patients with known allergies to lignocaine are excluded from the criteria.

A sample size of 122 dental professionals was determined to provide sufficient power to detect significant differences and trends. A stratified random sampling technique was employed to ensure representation across different geographic regions and practice settings (e.g., private practice, public clinics)

The questionnaire was designed based on a thorough review of the literature and consultation with experts in endodontics.

The study consisted of four sections:

1. Demographic Information: Age, gender, years of practice, type of practice, and geographic location.
2. Clinical Experience with Lignocaine: Frequency of use, dosage, and administration techniques.
3. Efficacy and Satisfaction: Perceived effectiveness, patient satisfaction, and comparison with other anesthetics.
4. Adverse Effects and Complications: Incidence and management of any adverse effects.

The questionnaire was pre-tested with a small group of dental professionals (n=10) to ensure clarity, relevance, and reliability. Responses from the pre-test were used to develop the questionnaire.

The survey was distributed electronically via email to a list of dental professionals obtained from dental associations and professional networks. Participants were provided with an information sheet detailing the purpose of the study, the voluntary nature of participation, and assurances of confidentiality and anonymity.

Statistical analysis was performed using a statistical software program Windows, Version 29 (SPSS). Data was entered in a Microsoft Excel spreadsheet and analyzed using SPSS software (version 29). For the test, a p-value of < 0.05 is to be considered statistically significant. The Chi-Square test was used to assess the descriptive statistics.

RESULTS

The present study was conducted among 122 dental practitioners In Pune, Maharashtra. The observations recorded are represented in Table 1. In this 119 (97.5%) were aware of the Effects of local anesthesia on the nerve while 3 (2.5%) were unaware of the same.

It was observed that 74 (60.7%) knew the ineffective action of lignocaine as a potential

complication while 38 (31.1%) were unaware. according to the participants 118 (96.7%) agreed that lignocaine has an effective anestheticpotency,4 (3.3%) stated that they disagree with the same.

A maximum number of participants 109 (89.3%) found that the combination of lignocaine with adrenaline provided profound anesthesia while 8 (6.6%) found lignocaine to be ineffective 5 (4.1%) were unaware. 110 (90.2%) used lignocaine for dental procedures 8 (6.6%)

Did not use lignocaine, while 4 (3.3%) did not answer. 97 (79.5%) agreed the pain relief from lignocaine to last for enough duration for root canal treatment while 17 (13.9%) found that it was insufficient based on their previous experiences. According to their professional experience71 (58.2%) stated that lignocaine numbed the area immediately after administration, while 45 (36.9%) stated that it did not. The duration of numbness was reported 30-60 minutes by 93 (76.2%) less than 30 minutes by 19 (15.6%), while only 10 (8.2%) stayed more than 90 minutes.

It was found that 77(63.1%) stated 2-5 minutes as the onset of action of lignocaine,21(17.2%) stated 1-2 minutes,16(13.1%) stated 5-10 minutes,3(2.5%) stated 10-30 minutes while only 4(4.1%) stated the onset to be immediate (fig1). It was observed that 82(67.2%) stated the pain rating to be 2-4 after administration of lignocaine, 21(17.2) stated 0-1,16(13.1%) Stated the rating to be 5-7 while only 3(2.5%) reported the rating to be 7-10.

It was found that all of the participants agreed that improper administration of lignocaine would lead to a reduction in its efficacy (Fig 6).

Table 1: Shows the responses of dentists to the questionnaire.

Question	yes	No	maybe
Effects of local anesthesia on the nerve supply	119(97.5%)	3(2.5%)	
ineffective action of lignocaine a potential complication	74(60.7%)	38(31.1%)	10(8.21%)
Does the combination of lignocaine with adrenaline provide profound anesthesia?	109(89.3%)	8(6.6%)	5(4.1%)
Do you know what is a "hot tooth"?	98(80.3%)	22(18.0%)	2(1.6%)
Alternative options to lignocaine for local anesthesia	105(86.1%)	7(5.71%)	10(8.21%)
Have you ever had any reservations or concerns about using lignocaine?	97(79.5%)	20(16.4%)	5(4.1%)
Would you be interested in learning more about lignocaine?	112(91.8%)	5(4.1%)	5(4.1%)
Is lignocaine effective in "hot tooth?	29(23.8%)	74(60.7%)	19(15.6%)
Would you recommend lignocaine to others based on your personal experience or knowledge?	111(91.0%)	6(4.9%)	5(4.1%)
Do you ask patients if they are taking any medications that may interact with lignocaine?	115(94.3%)	5(4.1%)	2(1.6%)
Do you feel other anesthetics give better anesthesia compared to lignocaine?	74(60.7%)	16(13.1%)	32(26.2%)
Have you ever used lignocaine for any medical or dental procedures?	110(90.2%)	8(6.6%)	4(3.3%)
Have you ever had any allergic incidents or adverse effects to lignocaine?	25(20.5%)	91(74.6%)	6(4.9%)
Do you expect the pain relief from lignocaine to last for enough duration based on your previous experiences?	97(79.5%)	17(13.9%)	8(6.6%)
Does lignocaine start to numb the area immediately after it is administered	71(58.2%)	45(36.9%)	6(5.0%)

In this study 98 (80.3%) knew about hot tooth while 22 (18.0%) did not only 2(1.6%) were unaware. 55 (45.1%) believed hot tooth was caused by bacterial toxins, 46(37.7%) believed it was caused by TXX receptor,10 (8.2%) believed it was due to patient threshold while only 11 (9.0%) stated that none of the above factors cause hot tooth(fig2). 29 (23.8%) stated that lignocaine was effective in hot teeth while 74 (60.7%) stated they found lignocaine to be ineffective in hot tooth only 19 (15.6%) were unsure regarding the same.

It was recorded that 91 (74.6%) did not have any adverse or allergic reaction to lignocaine while 25 (20.5%) had experienced some form of adverse effect or allergic reaction. The different allergic responses to lignocaine are described in (fig 9).

The type of lignocaine preferred for root canal treatment was lignocaine with adrenaline 1:1,20,000 by 95 (77.9%),26(21.3%) preferred lignocaine with adrenaline 1: 80000 only 1 (0.8%) preferred lignocaine without adrenaline(fig11). the technique of choice was injectable by 38 (31.1%), 4 (3.3%) reported topical while maximum 80 (65.6%) stated a combination of both was their treatment of choice(fig10).

The choice of technique for lower teeth is IANB by 32 (26%) while most 70 (57.4%) used a combination of IANB along with infiltration and intraligamentary as described in fig8.

It was observed that 105(86.1%) reported alternative options to lignocaine for anesthesia, while 7(5.7%) did not. 74(60.7%) reported other

anestheticagents have better potency than lignocaine while 16(13.1%) found lignocaine's potency to be sufficient. During lignocaine failure 87(71.3%) preferred bupivacaine, 14(11.5%) would use benzocaine while only 11(9.0%) would use Articaine (fig7).

Maximum participants 97(79.5%) had reservations about using lignocaine while 20(16.4%) did not. It was reported that 111(91.0%) would recommend lignocaine based on their previous experiences while 6(4.9%) would not. A maximum number of participants 112(91.8%) wanted to learn more about lignocaine and its properties, 5(4.1%) did not.

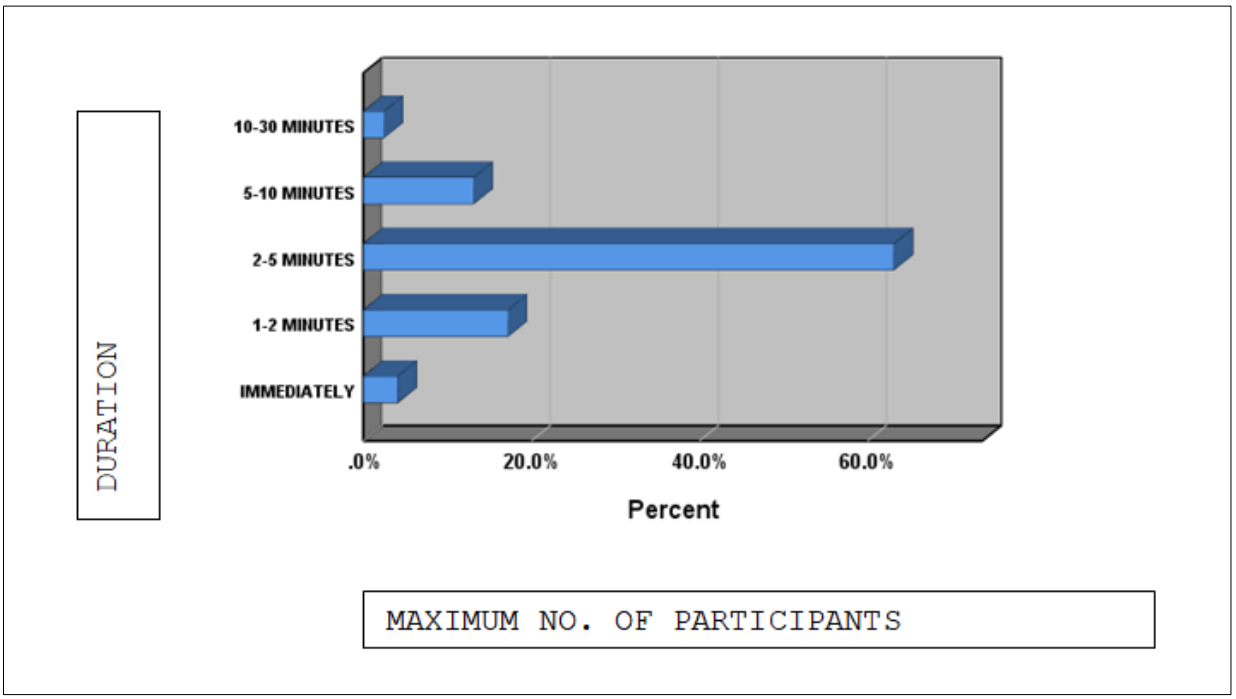

Fig. 1: shows the responses of dentists towards the onset of lignocaine

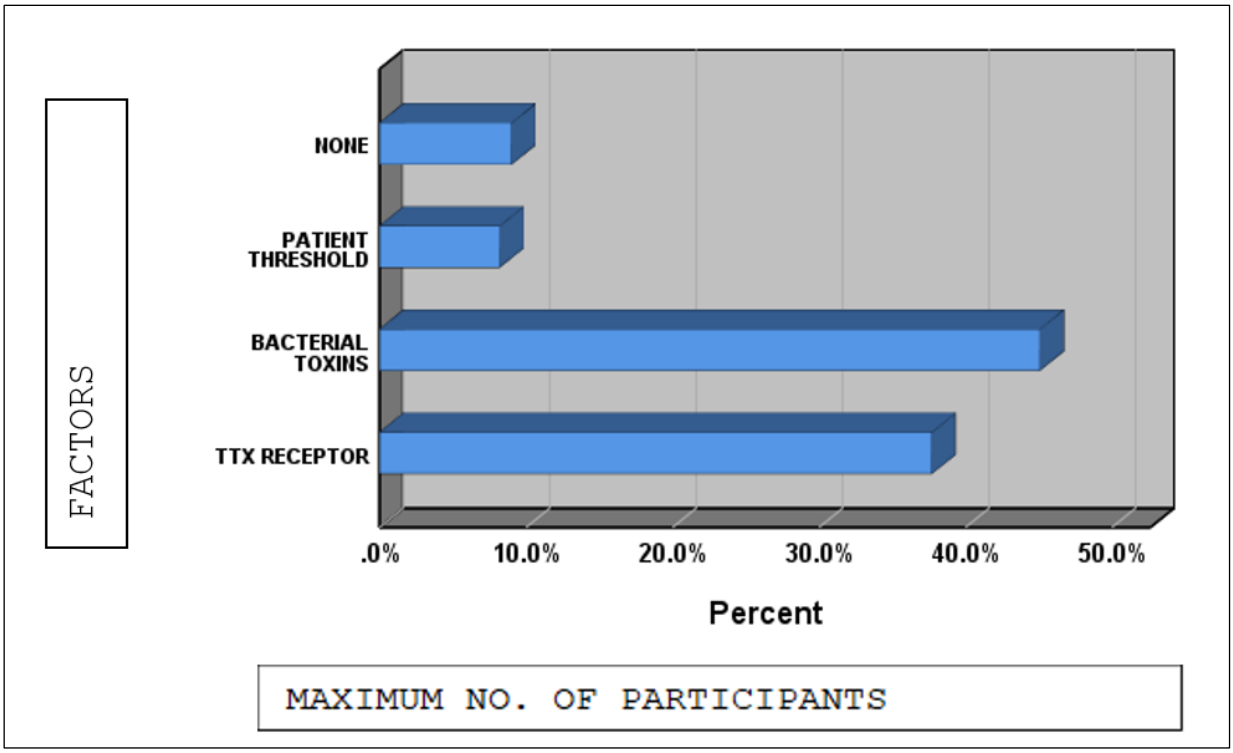

Fig. 2: showing the factors believed by dentists that cause hot tooth.

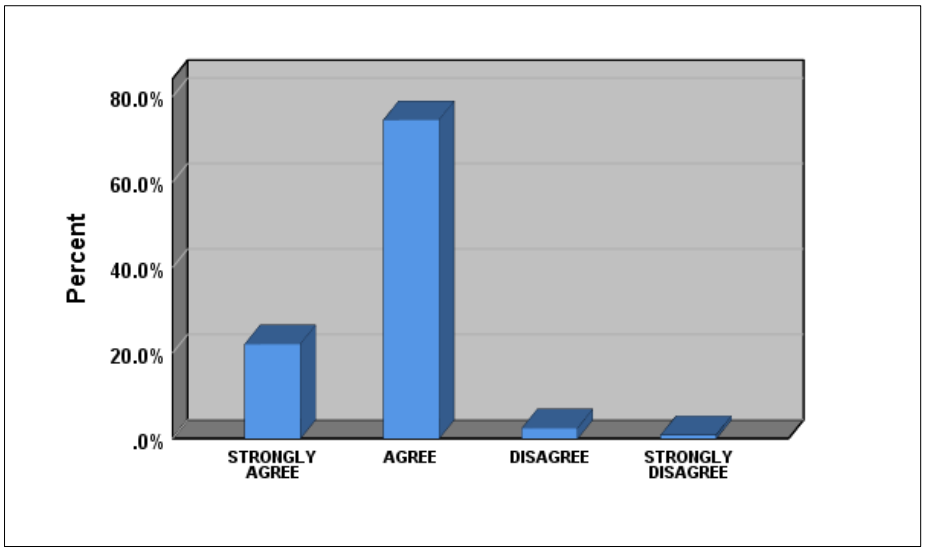

Fig. 3: shows the belief of the practitioner towards the efficacy of lignocaine as an anesthetic agent.

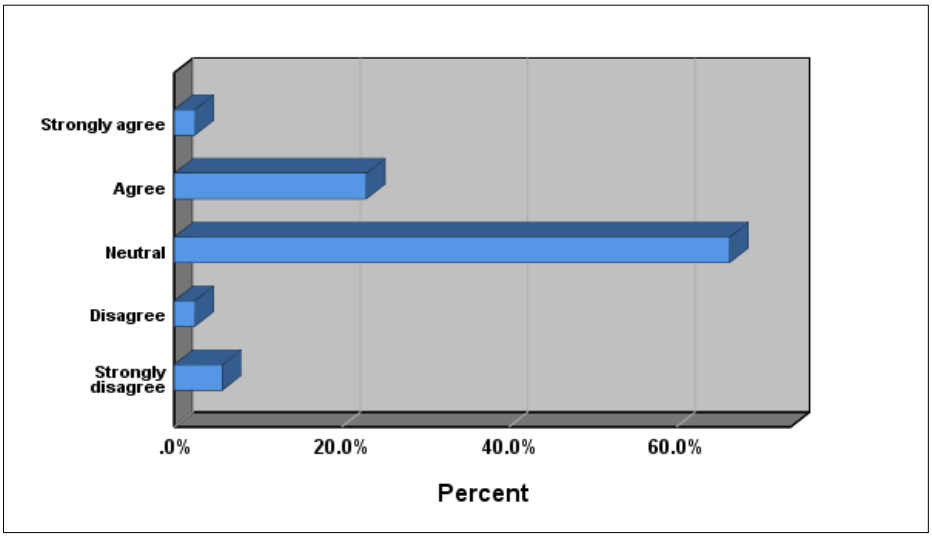

Fig. 4: shows the attitudes of participants towards the efficacy of lignocaine in comparison to other anesthetic agents

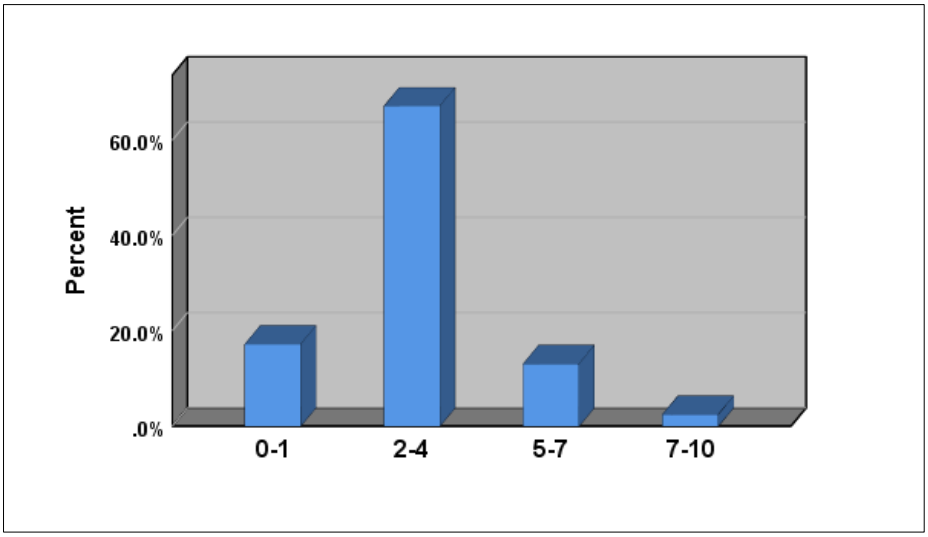

Fig. 5: shows the level of pain experienced after lignocaine administration.

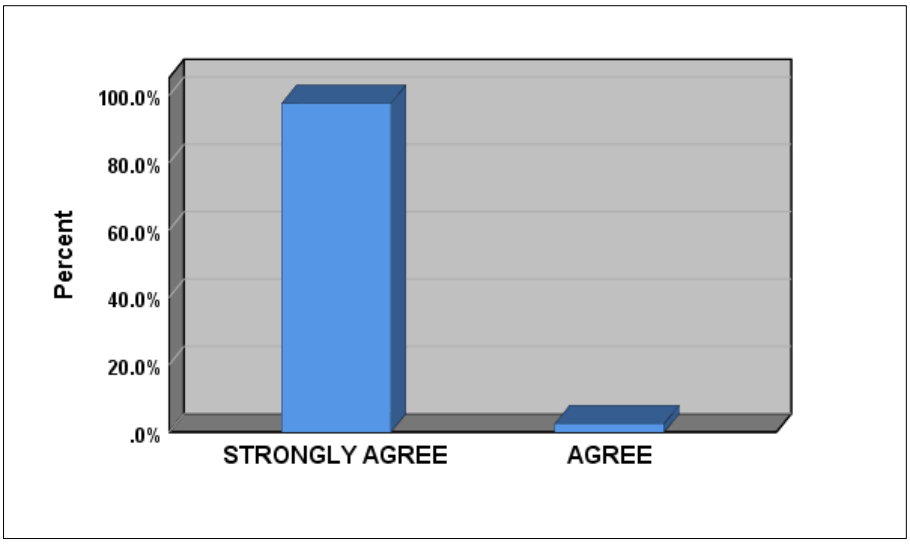

Fig. 6: shows the opinion of participants towards a decrease in lignocaine efficacy due to improper technique

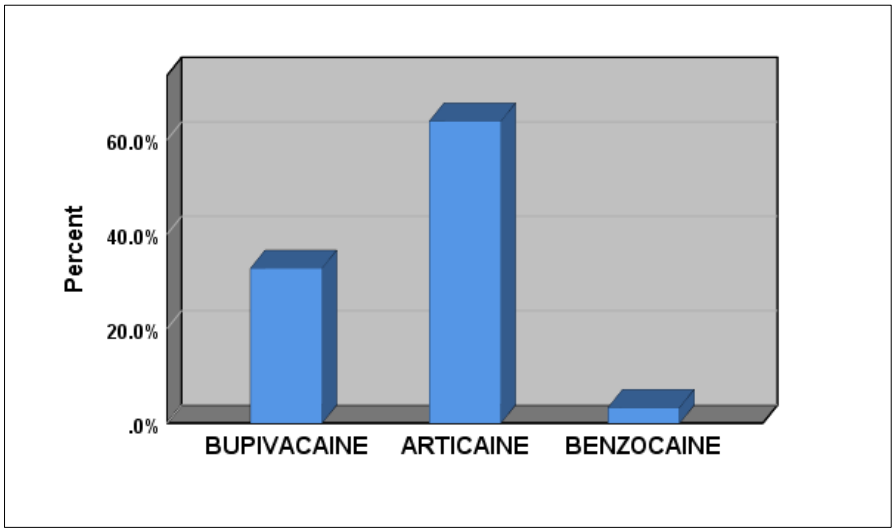

Fig. 7: shows the preference for an anesthetic agent in place of lignocaine

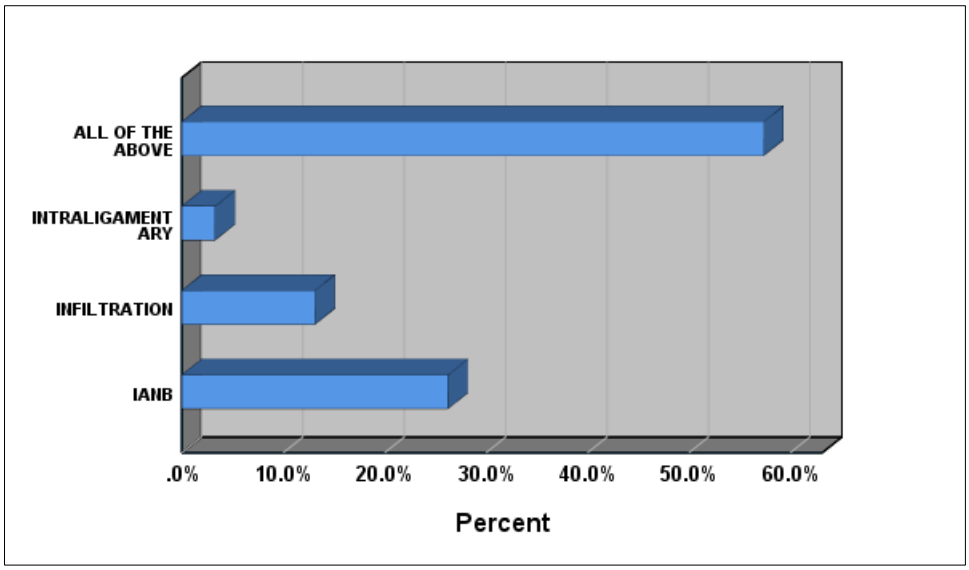

Fig. 8: shows the anesthetist technique preferred for lower molar root canal treatment.

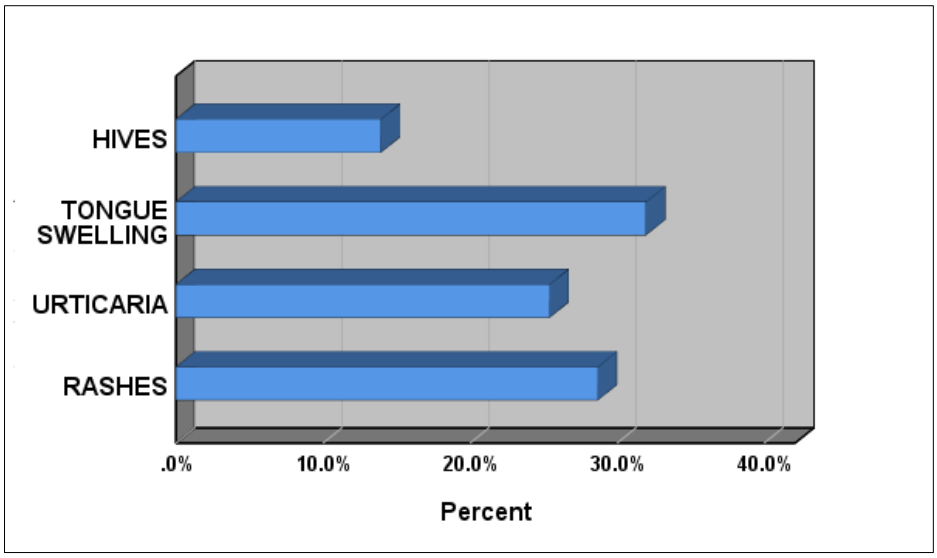

Fig. 9: shows the type of allergic reactions observed in the administration of lignocaine

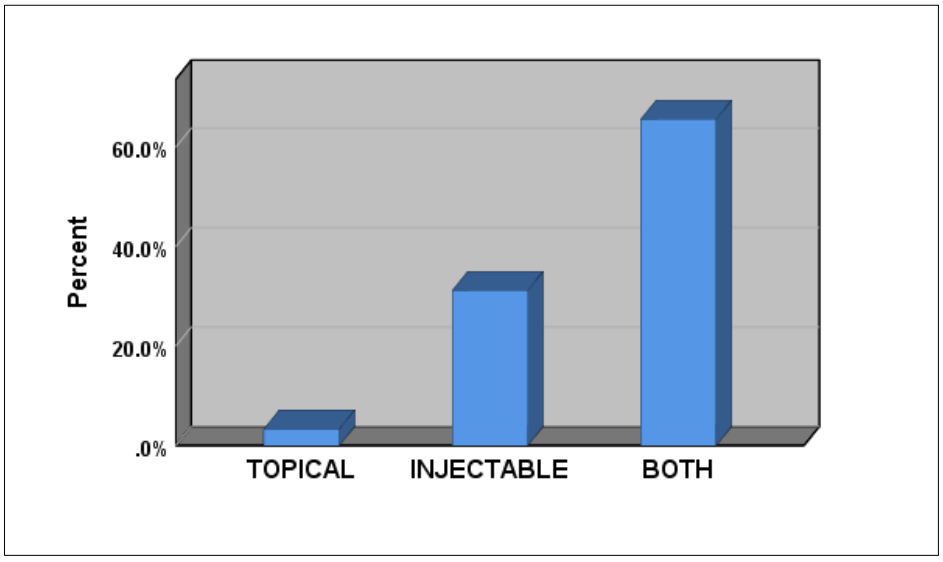

Fig. 10: shows the preference for the lignocaine technique during Root canal treatment

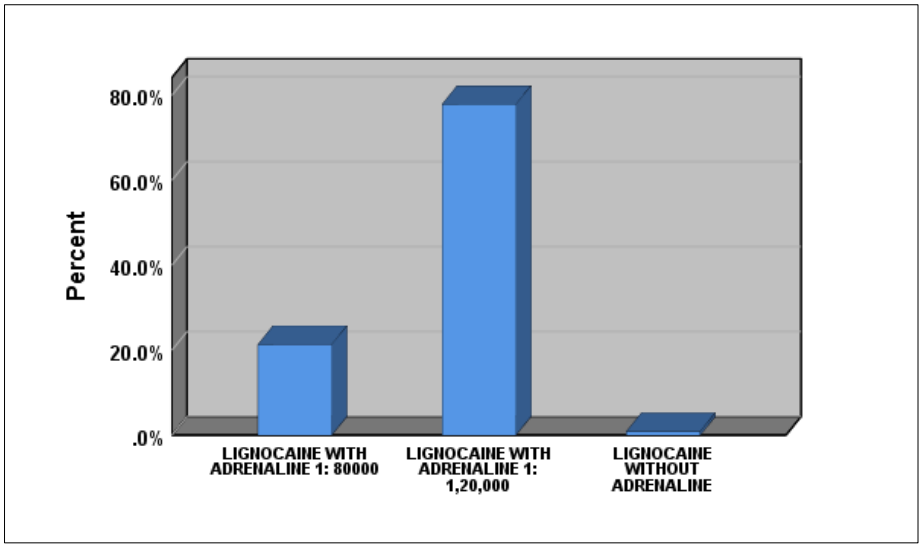

Fig. 11: shows the combination of lignocaine used during root canal treatment.

DISCUSSION

The present study sought to evaluate the efficacy of lignocaine as a local anesthetic during root canal treatment, using a clinician-focused questionnaire to assess real-world application and satisfaction. The results, compared with existing literature and alternative anesthetic agents, offer valuable insights into the effectiveness of lignocaine and potential improvements in clinical practice.

Lignocaine remains a cornerstone in the armamentarium of endodontic anesthetics, offering reliable and effective pain management for root canal treatment [2]. However, clinicians must be prepared to address its limitations in certain clinical scenarios, particularly in cases of severe pulpitis or infection. By adopting a flexible and informed approach to anesthesia, clinicians can ensure optimal patient care and treatment success. Continuing education on the latest anesthetic techniques and a thorough understanding of patient-specific factors will further enhance the efficacy of lignocaine in clinical practice.

Reliability and Onset of Action

Lignocaine is widely regarded by clinicians for its predictable onset of action and sufficient duration, making it a mainstay in dental anesthesia. In this study, lignocaine was effective in achieving adequate anesthesia for root canal treatment in the majority of cases. The rapid onset, typically within 2-3 minutes [13], allows for the timely commencement of procedures, which is crucial in a clinical setting where efficiency is essential. This characteristic reduces patient anxiety and enhances the overall flow of the treatment process which was reported by 63% of the clinicians based on their previous experiences.

Anesthetic Success in Various Clinical Scenarios

However, the study highlights an important clinical consideration: the reduced efficacy of lignocaine in patients presenting with acute pulpitis or severe infection. This is a well-documented challenge faced by endodontists, as the acidic environment associated with inflamed tissues can diminish the anesthetic efficacy of lignocaine. Clinicians must be aware of this potential limitation and be prepared to employ additional anesthetic techniques, such as administering supplementary injections (intraligamentary or intraosseous) or using adjunctive agents like articaine, which is more effective in such scenarios.

The study explored various techniques used by clinicians when administering lignocaine, especially for anesthetizing lower teeth, where achieving profound anesthesia is more challenging due to anatomical factors. The questionnaire revealed that the inferior alveolar nerve block (IANB) was the most commonly used technique for lower molars, with over 85% of clinicians relying on this method. This aligns with existing literature that identifies the difficulty in achieving consistent anesthesia in the mandible, where the dense cortical bone and the proximity of the nerve to the mandibular canal can complicate the diffusion of the anesthetic. The study's findings are consistent with those of Hargreaves and Keiser (2002), who noted that the success rate of IANB with lignocaine is lower in patients with symptomatic irreversible pulpitis. To overcome these challenges, many clinicians reported using supplemental techniques. Intraosseous and intraligamentary injections were frequently mentioned as effective adjuncts, particularly when the initial IANB failed to provide adequate anesthesia. These techniques allow the Anesthetic to bypass the dense bone and deliver it directly to the target area, thus increasing the likelihood of successful pain management. This approach is supported by research from Nusstein *et al*., (2005), which demonstrated the enhanced efficacy of intraosseous injections in achieving profound anesthesia in lower molars.

Comparison with Alternative Anesthetic Agents

In addition to assessing lignocaine, the study also gathered clinician opinions on the use of alternative anesthetic agents such as articaine, bupivacaine, and benzocaine. Notably, articaine was frequently mentioned as a preferred alternative in cases where lignocaine was less effective. Approximately 63.9% of clinicians reported using articaine as a secondary option, particularly in patients with severe pulpitis. Articaine's higher lipid solubility and ability to diffuse through tissues were cited as key advantages, corroborating findings from studies like those by Kanaa *et al*., (2012), which demonstrated articaine's superior efficacy in challenging cases. Bupivacaine, known for its longer duration of action, was also noted by most clinicians (32.8%) as beneficial for procedures expected to induce prolonged post-operative pain. However, its slower onset compared to lignocaine makes it less desirable as a primary agent for routine root canals, a sentiment echoed in studies by Moore *et al*., (2011) [10].

When compared with similar studies, the findings of this research align closely with the broader consensus on lignocaine's efficacy. For example, a study by Malamed *et al*., (2009) reported similar satisfaction rates among clinicians, noting lignocaine's consistent performance in routine dental procedures [2]. However, studies such as those by Parirokh and Abbott (2014) also emphasize lignocaine's reduced effectiveness in inflamed tissues, a limitation that was similarly noted in our study. Our study further adds to the discussion by quantifying clinician feedback through the questionnaire, which provides a more nuanced understanding of lignocaine's practical application. While other studies have predominantly focused on patient-reported outcomes or clinical trial data, the inclusion of clinician perspectives highlights the real-world challenges and adaptations required in endodontic practice [13].

The findings of this study are consistent with existing literature on the use of lignocaine with adrenaline in dental anesthesia. For example, Malamed *et al*., (2009) similarly found that lignocaine with 1:100,000 adrenaline provides optimal Anesthetic efficacy and duration for most dental procedures, including root canal treatments. However, the variability in success rates with IANB, particularly in cases of severe inflammation, is a recurring theme in both our study and others, such as those by Hargreaves and Keiser (2002), which suggest the need for alternative or supplemental techniques. When comparing lignocaine with adrenaline to other anesthetic agents, such as articaine, it becomes clear that while lignocaine remains the standard for its safety and reliability, articaine's superior bone penetration offers distinct advantages in certain clinical scenarios. This is particularly relevant in mandibular anesthesia, where articaine's ability to achieve profound anesthesia with buccal infiltrations often surpasses that of lignocaine, especially when traditional nerve blocks are insufficient.

Implications for Clinical Practice

The findings of this study suggest that while lignocaine remains a highly effective and preferred anesthetic for most root canal treatments, clinicians should consider alternative agents or supplementary techniques in cases where lignocaine's efficacy may be compromised. The insights from the questionnaire underscore the importance of individualized anesthetic strategies, particularly for patients presenting with conditions that may affect the pH of the tissue(16). Incorporating a broader range of anesthetic options, such as articaine for difficult cases or bupivacaine for extended pain management, can enhance patient outcomes and overall satisfaction. Furthermore, continued education on the pharmacodynamics of these agents and their appropriate use in varying clinical scenarios is essential for optimizing endodontic anesthesia.

Considerations for Lignocaine Allergy

The occurrence of a lignocaine allergy, which can manifest as localized reactions (such as swelling or rash) or more severe systemic responses (like anaphylaxis), requires clinicians to be cautious in their approach. For patients with a confirmed allergy to lignocaine, the use of alternative amide anesthetics, such as articaine, bupivacaine, or benzocaine, is recommended [21]. These agents have different chemical structures, reducing the likelihood of cross-reactivity. It was reported that 20.5% of clinicians had experienced some form of allergic reaction post-lignocaine administration. This is consistent with several studies, including those by Naguib *et al*., (2014) and Volcheck and Mertes (2019) [25], which have documented the low prevalence of true lignocaine allergies, estimating it to occur in less than 1% of the population. This aligns with the observations in our study, where most clinicians reported encountering lignocaine allergy only rarely. These studies emphasize the importance of distinguishing between true allergic reactions and adverse effects related to anxiety or vasovagal responses, which are more common and often mistaken for allergies. When lignocaine allergy is confirmed, the consensus across studies is to use alternative amide local anesthetics, such as articaine, benzocaine, or bupivacaine, as these agents have a lower likelihood of cross-reactivity due to their different chemical structures. This approach was similarly recommended by clinicians in our study, who frequently opted for these alternatives when managing allergic patients [27].

Limitations and Future Directions

While the study provides robust data on the efficacy of lidocaine, it is important to acknowledge its limitations. The sample size, though adequate, was relatively small and may not fully represent the broader population. Additionally, the study did not explore the efficacy of lidocaine in combination with other anesthetic agents or alternative methods such as preoperative analgesics or buffering solutions, which could further improve anesthetic outcomes. Future studies could explore these combinations and compare the efficacy of lidocaine with other anesthetics, such as articaine or bupivacaine, particularly in cases of severe pulpitis or infection. Moreover, research into patient-specific factors, such as genetic variations in anesthetic metabolism or individual pain thresholds, could provide insights into personalized anesthetic protocols [28].

CONCLUSION

In conclusion, lidocaine remains an effective and safe choice for local anesthesia in root canal treatment, offering reliable pain control for most patients, clinicians must be prepared to address its limitations in certain clinical scenarios, particularly in cases of severe pulpitis or infection. The questionnaire responses highlight the necessity of being prepared with alternative strategies in more challenging cases. By comparing lignocaine with other anesthetic agents and integrating clinician feedback, this study provides a comprehensive overview of current practices and potential areas for improvement in endodontic anesthesia. The study confirms that lignocaine with adrenaline is an effective and reliable anesthetic for root canal treatment, particularly in lower teeth. However, challenges such as reduced efficacy in inflamed tissues and the anatomical complexity of the mandible necessitate the use of supplemental techniques like intraligamentary and intraosseous injections. The standard adrenaline concentration of 1:100,000 is generally sufficient, but adjustments may be required based on patient health and procedural needs Clinicians should be flexible and well-versed in various techniques and adrenaline ratios to optimize anesthesiain endodontic treatments. Future research should focus on further refining these strategies, including the development of protocols for the use of alternative agents in specific

clinical scenarios, research into alternative anesthetic agents and techniques will further enhance the efficacy of root canal treatments and improve patient outcomes.

REFERENCES

1. Sruthi, M. A., & Ramakrishnan, M. (2021). Transpapillary Injection Technique as a Substitute for Palatal Infiltration: A Split-mouth Randomized Clinical Trial. *Int J Clin Pediatr Dent, 14*(5), 640-643.
2. Reed, K. L., Malamed, S. F., & Fonner, A. M. (2012). Local anesthesia part 2: technical considerations. *Anesth Prog, 59*(3), 127-36, quiz 137.
3. Decloux, D., & Ouanounou, A. (2020). Local anesthesia in dentistry: a review. *Int Dent J, 71*(2), 87-95.
4. Tomaszewska, I. M., Zwinczewska, H., Gładysz, T., & Walocha, J. A. (2005). Anatomy and clinical significance of the maxillary nerve: a literature review. *Folia Morphol (Warsz), 74*(2), 150-6.
5. Somayaji, S. K., Acharya, S. R., Mohandas, K. G., & Venkataraman, V. (2012). Anatomy and clinical applications of the mandibular nerve. *Bratisl Lek Listy, 113*(7), 431-40.
6. Wang, Y. H., Wang, D. R., Liu, J. Y., & Pan, J. (2021). Local anesthesia oral and maxillofacial surgery: A review of current opinion. *J Dent Sci, 16*(4), 1055-1065.
7. Meechan, J. G. (2002). Supplementary routes to local anesthesia. *Int Endod J, 35*(11), 885-96.
8. Takezawa, K., Ghabriel, M., & Townsend, G. (2018). The course and distribution of the buccal nerve: clinical relevance in dentistry. *Aust Dent J, 63*(1), 66-71.
9. Ingle, J. I., Bakland, L. K., & Baumgartner, J. C. (2008). Mechanism of odontogenic and non-odontogenic pain. In: Gibbs JL, Hargreaves KM, editors. Ingle's Endodontics 6. BC Decker; 376.
10. Moore, P. A., & Dunsky, J. L. (1983). Bupivacaine anesthesia--a clinical trial for endodontic therapy. *Oral Surg Oral Med Oral Pathol, 55*, 176–9.
11. Byers, M. R., Taylor, P. E., Khayat, B. G., & Kimberly, C. L. (1990). Effects of injury and inflammation on pulpal and periapical nerves. *J Endod, 16*, 78–84.
12. Wong, M. K., & Jacobsen, P. L. (1992). Reasons for local anesthesia failures. *JAmDentAssoc, 123*, 69–73.
13. Quinn, C. L. (1998). Injection techniques to anesthetize the difficult tooth. *J CalifDentAssoc, 26*, 665–7.
14. Hargreaves, K. M., & Keiser, K. (2002). Local Anaesthetic failure in endodontics. *Endodontic Topics, 1*, 26–39.
15. Marshall, J. G., & Walton, R. E. (1984). The effect of intramuscular injection of steroid on posttreatment endodontic pain. *J Endod, 10*, 584–8.
16. Marković, A. B., & Todorović, L. (2006). Postoperative analgesia after lower third molar surgery: contribution of the use of long-acting local anesthetics, low-power laser, and diclofenac. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod, 102*, e4–8.
17. Fisher, S. E., Frame, J. W., Rout, P. G., & McEntegart, D. J. (1988). Factors affecting the onset and severity of pain following the surgical removal of unilateral impacted mandibular third molar teeth. *Br Dent J, 164*, 351–4.
18. Gregorio, L. V., Giglio, F. P., Sakai, V. T., Modena, K. C., Colombini, B. L., Calvo, A. M., Sipert, C. R., Dionísio, T. J., Lauris, J. R., Faria, F. A., Trindade, J. A. S., & Santos, C. F. (2008). A comparison of the clinical Anaesthetic efficacy of 4% articaine and 0.5% bupivacaine (both with 1:200,000 epinephrine) for lower third molar removal. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod, 106*, 19–28.
19. Corbett, I. P., Ramacciato, J. C., Groppo, F. C., & Meechan, J. G. (2005). A survey of local anesthetics among general dental practitioners in the U.K. attending post-graduate courses on pain control. *Br Dent J, 199*, 784–7.
20. Brunetto, P. C., Ranali, J., Ambrosano, G. M., de Oliveira, P. C., Groppo, F. C., Meechan, J. G., & Volpato, M. C. (2008). Anesthetic efficacy of 3 volumes of lidocaine with epinephrine in maxillary infiltration anesthesia. *Anesth Prog, 55*, 29–34.
21. Shahi, S., Rahimi, S., Yavari, H. R., Ghasemi, N., & Ahmadi, F. (2018). Success rate of 3 injection methods with articaine for mandibular first molars with symptomatic irreversible pulpitis: a CONSORT randomized double-blind clinical trial. *Journal of Endodontics, 44*(10), 1462–1466.doi:10.1016/j.joen.2018.07.010.
22. Sherman, M. G., Flax, M., Namerow, K., & Murray, P. E. (2008). Anesthetic efficacy of the Gow-Gates injection and maxillary infiltration with articaine and lidocaine for irreversible pulpitis. *Journal of Endodontics*, *34*(6), 656-659.
23. Dou, L., Vanschaayk, M. M., Zhang, Y., Fu, X., Ji, P., & Yang, D. (2018). The prevalence of dental anxiety and its association with pain and other variables among adult patients with irreversible pulpitis. *BMC oral health, 18*, 1-6.
24. Zanjir, M., Lighvan, N. L., Yarascavitch, C., Beyene, J., Shah, P. S., & Azarpazhooh, A. (2019). Efficacy and safety of pulpal anesthesia strategies during endodontic treatment of permanent mandibular molars with symptomatic irreversible pulpitis: a systematic review and network meta-analysis. *Journal of Endodontics*, *45*(12), 1435-1464.
25. Subbiya, A., & Pradeepkumar, A. R. (2016). Pain management in endodontics. *Journal of Operative Dentistry & Endodontics*, *1*(2), 76-81.
26. Kim, H., Lee, J. M., Seo, K. S., Kwon, S. M., & Row, H. S. (2019). Anaphylactic reaction after local lidocaine infiltration for retraction of retained teeth. *Journal of dental anesthesia and pain medicine*, *19*(3), 175-180.
27. Khandelwal, M., Saini, V. K., Kothari, S., & Sharma, G. (2018). Role of lignocaine nebulization as an adjunct to airway blocks for awake fiber-optic intubation: a comparative study. *Anesthesia Essays*

and Researches, *12*(3), 735-741.

28. Suryawanshi, T., Jadhav, A., Gupta, A., Agrawal, P., & Sharma, A. (2022). Comparative Analysis of Anaesthetic Efficacy of 2% Lignocaine with Dexmedetomidine as an Adjunct in Nerve Blocks for Dental Extractions: A Randomised Controlled Study. *Cureus*, *14*(9).