Review Article

Evolution of dental anesthesia: a narrative review of innovations in preclinical teaching and clinical care

Bernadette Alvear Fa^, Laura Reid

Department of Preventive and Restorative Dentistry, University of the Pacific, Arthur A. Dugoni School of Dentistry, San Francisco, USA

Contributions: (I) Conception and design: BA Fa; (II) Administrative support: L Reid; (III) Provision of study materials or patients: BA Fa; (IV) Collection and assembly of data: Both authors; (V) Data analysis and interpretation: Both authors; (VI) Manuscript writing: Both authors; (VII) Final approval of manuscript: Both authors.

Correspondence to: Bernadette Alvear Fa, DDS. Associate Professor, Department of Preventive and Restorative Dentistry, University of the Pacific, Arthur A. Dugoni School of Dentistry, 155 5th Street, San Francisco, CA 94103, USA. Email: balvear@pacific.edu.

Objective: The purpose of this article is to describe history and current methods of innovative tools used to learn and administer dental anesthesia.

Background: In the past five years, technology innovations for learning dental anesthesia have been constant. Some innovations seek to aid local anesthesia didactic learning and others increase local anesthesia clinical efficacy. Additional advantage from innovations used in preclinical teaching is ability to model communication with novice oral healthcare providers to help with patient-centered care. Clinical application of new dental technology has more credibility now than it ever had in the past. This article reviews literature in the past five years discussing dental anesthesia for preclinical curricula and innovative technology used to increase efficacy of local anesthesia for clinical dental procedures.

Methods: Authors present innovations in preclinical dental anesthesia and contemporary dental anesthesia technology applied in clinical practice.

Conclusions: Dental anesthesia is presented and learned in more ways than traditional methods. Newer innovations have elevated dental anesthesia to a new level of patient comfort and oral healthcare provider safety. Advancements in preclinical education are the new normal, with technology providing flexibility for different learning styles, making learning deeper and more meaningful and better preparing the students for transition to clinical learning on live patients. Dental anesthesia is being taught differently with advanced innovations, but one constant remains: patient pain management cannot be compromised.

Keywords: Dental anesthesia; pain management; technology; innovations

Received: 12 October 2021. Accepted: 16 January 2022.
doi: 10.21037/joma-21-9
View this article at: https://dx.doi.org/10.21037/joma-21-9

Introduction

One constant in today's world is change. Change in dental anesthesia has been a vital factor in its multifactorial process. Further preclinical dental education traditionally consists of lecture seminars, anatomic models, and peer-to-peer injections as a method of learning (1). Importance of learning dental anesthesia requires understanding elements of pharmacology along with head and neck anatomy. Chapters in dental anesthesia textbooks dedicate much to discussing the trigeminal nerve and its branches innervating teeth (2-5). Not knowing specifics of the trigeminal nerve and its branches would be a disservice to patients receiving care (6).

As technology advances, changes are adopted and

^ ORCID: 0000-0001-7444-2192.

Table 1 Sources used for overview from past 5 years

Sources	Keywords/specifics of search
NCBI	Innovation in preclinical dental anesthesia
Google Scholar	Dental anesthesia education, preclinical dental anesthesia, innovation, technology in pain management
Personalized search of text using institutional database	Hand searches of references of retrieved literature

NCBI, National Center for Biotechnology Information.

used to educate oral healthcare professionals (OHP) (7). Dental anesthesia addresses pain management and is essential in the dental profession (6,8-11). This article summarizes innovations developed over the last five years with preclinical dental anesthesia curricula and the advancing technology in clinical practice for administering local anesthesia safely and comfortably. We present the following article in accordance with the Narrative Review reporting checklist (available at https://joma.amegroups.com/article/view/10.21037/joma-21-9) (12).

Methods

Information gathered to write this article is presented in *Table 1*. Data collected was from literature from 2016 to 2021. Keywords to help search were initially preclinical dental anesthesia, innovation in dental anesthesia, and technology in pain management. From the searches, articles were specific to adult population and then further specified for topics presented in article.

Innovations in dental education

Learning dental local anesthesia is a multifactorial process, advancements in preclinical education provide opportunities for OHP to learn beyond lecture and seminar. Traditional methods of teaching OHP involves reviewing material found in textbooks and in person lectures (1). As we look towards the future, our article will acknowledge the changes in technology and its uses in dental curriculums.

Online resources

For decades, interestingly, OHP were offered continuing dental education online opportunities. Various dental organizations and dental companies were already reaching OHP with online dental content (13-16).

Five to ten years ago, subscription-based software programs started to be utilized to engage students with online self-guided learning. The program Softchalk® was implemented in various curricula and used help to learn anatomy and deliver additional content in dentistry (17-20). The software program enabled educators using Canvas®, the institutional intranet system, to create their own engaging, interactive content, add it to their courses via the intranet system and record detailed student score results for their SoftChalk® content into the Canvas® gradebook. Recent methods of learning dentistry have become more progressive, yet when the world was faced with the Covid-19 pandemic necessitating all didactic content to be delivered online, educating OHP drastically changed. Educators became more creative with content delivery and additional online resources were explored to optimally deliver certain details of courses (15,16,21,22).

Technology such as Zoom® allowed predoctoral OHP to meet on virtual platforms and break into smaller discussion groups to deepen learning of the course material (16,23). Zoom® is a cloud-based peer-to-peer videoconferencing software platform that allows faculty to connect with students via their laptops or phones and deliver course content. Zoom® enables face to face interactions and faculty can display lecture content as well as break students into smaller discussion groups or "break out rooms" (*Figure 1*).

Programs such as WebEx®, Microsoft Teams®, Google groups® are other platforms available for digital teaching and group breakouts. COVID-19 necessitated use of technology to teach students preclinical material that was once taught in person. These technologies are being used rather universally in the preclinical dental curricula (15-19,22-25). Another advantage from innovations discussed above is the ability to model communication with novice OHP to help with patient-centered care (6). As telehealth progresses in medicine, we recognize that proximity barriers need to be removed and communication is essential.

Figure 1 Small Group Zoom® Break Out Sessions (this image is published with the participants' consent).

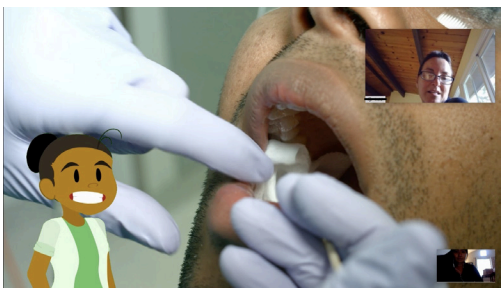

Figure 2 Online session (small group) with mixed media video (this image is published with the patient/participant's consent).

Institutional programs continued in their advancements online and others introduced sites such as Osmosis.org to help with reviewing curricular (24,25). Osmosis® medical is a medical education platform that offers high quality animated videos on medical school subjects and clinical content. They have over 1,800 videos offering content on basic sciences (anatomy, physiology, biochemistry, pharmacology, and similar subjects), and other medical school content such as organ system review, pathology, clinical reasoning.

Videos

Videos have been used for decades in other professions and were always a popular adjunct to traditional lectures but are now becoming more popular for dental education content (26). With upgrades to different technologies from cameras to lenses, audio, and editing features, video technology is more advanced and particularly aids those who are visual learners (*Figure 2*).

Step by step videos help students learn various aspects of head and neck anatomy important for dental anesthesia. Mixed media using animation has been adopted within the past 5 years (26-29). The use of upgraded technology to capture high-definition quality video makes the imagery more detailed, more compelling, and arguably enables more effective learning. Video content also allows for more creative presentation styles, such as a karaoke video using music of generational genre to make normally dry didactic information a bit more 'memorable' for students before they enter clinical patient care (30). YouTube® is also a platform that has various videos available, but disclosures need to be mentioned to OHP about the credibility of content presented.

Virtual reality and hands on haptic technology

Virtual reality has been employed for both dental students and dental patients. Virtual reality learning in dentistry, where instruments are being used for procedures, generally includes a haptic interface. Haptic means "to touch". The most common type of haptic interface provides force feedback, giving the student real-time information about their force or pressure on the instrument. Hands-on haptic technology combined with virtual reality technology has enabled students to learn how to correctly hold a dental syringe virtually, to find anatomical landmarks important for delivering dental local anesthesia virtually and has allowed dental students to attempt an injection using a virtual reality scene. For dental patients with dental fear and anxiety, virtual reality allows the dental patient as many virtual contact experiences as necessary for desensitization and anxiety reduction prior to dental procedures (31-34). OHP outcomes with haptic technology and virtual reality have been favorable, but further study to evaluate efficacy is needed.

Innovation in clinical application

Many local anesthesia clinical advances have been made in the global dental market. Discussion presented is limited to local anesthesia innovations in the United States marketplace.

Hypnosis

A technique used in the past that was not considered favorable in medical communities or in Western culture, has begun to gain momentum in dental anesthesia (35,36). Recent studies suggest that hypnosis is possible and offers an alternative option other than pharmaceuticals for patients seeking dental care. A recent case study presented three clinical situations where patients were able to undergo dental treatment with the use of hypnotic therapy without administration of dental anesthesia. This technique, although not foreign, is becoming more accepted in western society (36,37). Patients benefit from this alternative technique avoiding needle injections and local anesthetic medications that must be processed by the body. Hypnosis provides dental practitioners another patient management option and allows OHP to offer a less invasive alternative for providing dental care to their patients. Hypnosis is a specific technique not frequently taught as a preclinical technique, however, the understanding of using calming techniques to help with patient management is discussed for a better patient experience (6).

Buffering

Commercial local anesthetic solutions have an acidic pH to maximize water solubility and chemical stability. Some of the acidic form of this local anesthetic must be deionized to penetrate the lipid bilayer, enter cells, and become effective. While it takes some time for the body to naturally buffer injected acidic local anesthetic solution, buffering can be accomplished in the syringe seconds before injection. Studies suggest this leads to faster, more profound local anesthesia and greater patient comfort at the injection site (38-41). Currently, there are two buffering systems available for dental anesthesia. Some institutions and affiliated clinical programs are applying the use of buffering in patient care.

The Anutra® System, introduced in 2015, uses a haptic syringe, and a mixing system using multidose vial of 2% Lidocaine HCl 1:100,000 epinephrine to combine 8.4% sodium bicarbonate (*Figures 3*,*4*).

The Onset Buffering Pen by Onpharma® is approved by the US Federal and Drug Agency to be used with all available dental anesthetics in the United States. The system uses its pen to calculate the precise amount of 8.4% sodium bicarbonate to be exchanged into the dental anesthetic cartridge (42). Due to the precise exchange, the pH of the anesthetics comes out to about 7.4, physiologic pH. Once the cartridge is buffered, it should be injected immediately (*Figure 5*).

Computer controlled local anesthesia device (CCLAD)

The introduction of CCLAD began in late 1990 (43). Milestone Scientific®, was the pioneering system that helped get the CCLAD credibility in dental anesthesia. Over time, more companies developed CCLAD with the purpose of controlling the speed of anesthesia delivery to create a painless injection (8,44,45). Through innovations and updates, the Wand/STA® is now a system that works using a foot pedal to control anesthetic delivery through a handpiece that does not resemble a standard syringe. This attached system provides a more ergonomic option for OHP and comes with an audible indicator of anesthetic delivery speed.

Figure 3 Anutra® Medical Buffering system.

Figure 4 Anutra® Medical haptic syringe.

Figure 5 View of sodium bicarbonate cartridge for Onset Buffering Pen System®.

Recently, Dentapen® was launched in the United States as a battery-operated CCLAD. This system is equipped with a wireless battery-operated device, cartridge container, and handles to control the CCLAD system. The two handles create an ergonomic pen grasp hold of the CCLAD for the OHP. Once disassembled, the cartridge container and handles can be placed into autoclave or wiped with disinfectant wipes. The battery-operated unit can be disinfected using disinfecting wipes.

Retraction and oscillation

The Dental Vibe® is a system that adds an element of safety for the OHP and comfort during delivery for the patient. This system is based on the Gate Theory of pain and the limited capacity of the body to perceive many stimuli at once (46-48). The system includes a rechargeable unit that uses a disposable tip to retract and provide light and oscillation of the tissue during injection. The use of disposable tip helps reduce risk of intraoral needlestick injury by removing the retracting finger from the intraoral mucosa (49-51). For OHP, the Dental Vibe allows for instrument rather than finger retraction while administering local anesthesia, which has been proven to lead to less needlestick injury, particularly in newer practitioners who have less local anesthesia experience (51-53). The oscillating vibrations send pulsations deep into the tissue to stimulate firing of alpha fibers and distract the patient from needle insertion and the pain (48,49,54,55) (*Figure* 6). Currently, there are several institutions in the United States using the Dental Vibe (*Figure* 7) in clinical application while others are teaching use of instrument retraction in preclinical teaching and clinical application.

Discussion

Advancements in preclinical education are the new normal, with technology providing flexibility for different learning styles, making learning deeper and more meaningful and better preparing the students for transition to clinical learning on live patients. By contrast, advancements in clinical education have greater patient safety and comfort in mind as well as greater provider safety and efficacy when delivering local anesthesia. Innovation and technology advancements in clinical education must necessarily benefit both OHP and the patient. Technology advancements in the total educational program, which necessitates discussion of both preclinical and clinical advancements merits further study. Bringing awareness to growth and new developments helps broaden the opportunities for OHP in preclinical education and clinical application.

Because the innovations mentioned above are

Figure 6 Dental Vibe® system used in delivery of mandibular block technique (this image is published with the patient/participant's consent).

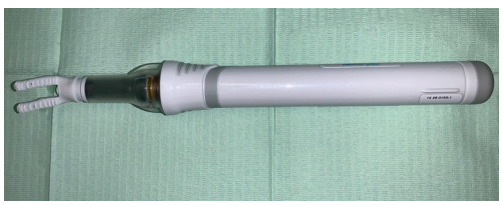

Figure 7 Cordless oscillating system with moveable prongs for one-time patient use.

contemporary, not all dental school curriculums are applying use of the technology discussed.

Limitations to having access to innovations and technology discussed may be financial, calibration of faculty, and availability of a reliable internet source. Other limits to our article are the focus on dental local anesthesia. Unfortunately, other alternative treatments, such as intravenous sedation was not discussed. More data and of the efficacy of intravenous sedation has been further evaluated and concludes great benefit for clinical application (56).

Conclusions

Local anesthesia teaching methods and local anesthesia clinical technology is being consistently improved. With technology and innovations being introduced, education and clinical application continue to progress.

More studies will be needed to evaluate both teaching methods using new technology and chairside devices seeking to improve the local anesthesia clinical experience for both the dentist and the patient. As OHP improve in clinical care, more data should be collected to determine success or failure of local anesthesia during patient care. One factor that is absolute, and should not change, is the focus on maintaining profound anesthesia for patient treatment in dentistry.

Acknowledgments

The authors would like to acknowledge the University of the Pacific, Arthur A. Dugoni School of Dentistry in San Francisco, CA. In addition, we would like to also thank Ms. Dominique Winfield, Dr. Bina Surti, and Mr. Michael Interrante.

Funding: None.

Footnote

Reporting Checklist: The authors have completed the Narrative Review reporting checklist. Available at https://joma.amegroups.com/article/view/10.21037/joma-21-9/rc

Peer Review File: Available at https://joma.amegroups.com/article/view/10.21037/joma-21-9/prf

Conflicts of Interest: Both authors have completed the ICMJE uniform disclosure form (available at https://joma.amegroups.com/article/view/10.21037/joma-21-9/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

References

1. Kary AL, Gomez J, Raffaelli SD, et al. Preclinical Local Anesthesia Education in Dental Schools: A Systematic Review. J Dent Educ 2018;82:1059-64.
2. Malamed SF. Handbook of local anesthesia. Elsevier Health Sciences, 2014:186-203.
3. Liebgott B. The Anatomical Basis of Dentistry. Elsevier Health Sciences, 2017:493-505.
4. Meechan JG. Practical Dental Local Anaesthesia: 6 (Quintessentials: Oral Surgery & Oral Medicine). Quintessence Publishing Co Ltd., 2019.
5. Monheim LM. Local anesthesia and pain control in dental practice. CV Mosby Company, 1965:33-78.
6. Brady M, Fa BA. Pain Management in Patient-Centered Care. Available online: https://decisionsindentistry.com/article/pain-management-in-patient-centered-care/
7. Glick M. Dentistry at a crossroads. J Am Dent Assoc 2018;149:565-6.
8. Reader A, Nusstein J, Drum M. Successful local anesthesia for restorative dentistry and endodontics. Quintessence Publishing Company Incorporated, 2017.
9. Saxena P, Gupta SK, Newaskar V, et al. Advances in dental local anesthesia techniques and devices: An update. Natl J Maxillofac Surg 2013;4:19-24.
10. Jung RM, Rybak MA, Milner PT, et al. Local anesthetics and advances in their administration–an overview. J Pre Clin Clin Res 2017;11:94-101.
11. Malamed SF, Reed KL, Okundaye A, et al. Local and Regional Anesthesia in Dental and Oral Surgery. In: Complications of Regional Anesthesia. Springer, Cham, 2017:341-58.
12. Green BN, Johnson CD, Adams A. Writing narrative literature reviews for peer-reviewed journals: secrets of the trade. J Chiropr Med 2006;5:101-17.
13. Guttmann GD, Ma TP, MacPherson BR. Making gross anatomy relevant to dental students. J Dent Educ 2003;67:355-8.
14. Oliver G, DavidD A, Bell C, et al. An Investigation into Dental Local Anaesthesia Teaching in United Kingdom Dental Schools. SAAD Dig 2016;32:7-13.
15. Chang TY, Hong G, Paganelli C, et al. Innovation of dental education during COVID-19 pandemic. J Dent Sci 2021;16:15-20.
16. Iyer P, Aziz K, Ojcius DM. Impact of COVID-19 on dental education in the United States. J Dent Educ 2020;84:718-22.
17. Carr J. Effectiveness of pre-learning online modules in the first year medical school curriculum (Doctoral dissertation, Boston University). Available online: https://www.proquest.com/docview/1814764421?pq-origsite=gscholar&fromopenview=true
18. Machado RA, Bonan PRF, Perez DEDC, et al. COVID-19 pandemic and the impact on dental education: discussing current and future perspectives. Braz Oral Res 2020;34:e083.
19. Deery C. The COVID-19 pandemic: implications for dental education. Evid Based Dent 2020;21:46-7.
20. Zheng M, Ferreira L. Gamification to enhance online learning and engagement. J Dent Educ 2020. [Epub ahead of print]. doi: 10.1002/jdd.12296.
21. Miller CJ, Aiken SA, Metz MJ. Perceptions of D.M.D. student readiness for basic science courses in the United States: can online review modules help?. Eur J Dent Educ. 2015;19:1-7.
22. Druzinsky R, Doubleday A. Tablets in the Gross Anatomy and Neuroanatomy Labs: Quick and Dirty Can Work. FASEB J 2015;29:209-5.
23. Chen E, Kaczmarek K, Ohyama H. Student perceptions of distance learning strategies during COVID-19. J Dent Educ 2020. [Epub ahead of print]. doi: 10.1002/jdd.12339.
24. Morandini AC, Ramos-Junior ES, Zheng M, et al. Embracing video production as a powerful tool in dental education. J Dent Educ 2020. [Epub ahead of print]. doi: 10.1002/jdd.12246.
25. Tyson C. Osmosis. J Med Libr Assoc 2020;108:345-8.
26. Wong G, Apthorpe HC, Ruiz K, et al. An innovative educational approach in using instructional videos to teach dental local anaesthetic skills. Eur J Dent Educ 2019;23:28-34.
27. Fa BA, Radif M, Surti B, et al. Using Sharpie® to Increase Safey in Local Anesthesia during COVID. JADA + COVID-19 Monograph: Dentistry has met pandemic's challenges. ADA Morning Huddle; 2021. Available online: https://pages.ada.org/en/covidmonograph/using-sharpie-to-increase-safety-in-local-anesthesia-during-covid-dr.-bernadette-alvear-fa
28. Fa BA, Interrante MA, Castagna DM. Pilot study implementing mixed media and animation into the Preclinical Dental Anesthesia Course. J Dent Educ 2020;84:1046-52.
29. Lone M. Innovative strategies for teaching anatomy to dental students (Doctoral dissertation, University College

Cork). Available online: https://cora.ucc.ie/bitstream/handle/10468/5535/Innovative%20strategies%20for%20teaching%20anatomy%20to%20dental%20students.pdf?sequence=1&isAllowed=y
30. Fa BA, Navas AE, Cochnauer HA, et al. Karaoke inspired anesthesia. J Dent Educ 2020. [Epub ahead of print]. doi: 10.1002/jdd.12504.
31. Corrêa CG, dos Santos Nunes FD, Tori R. Virtual reality-based system for training in dental anesthesia. In: International Conference on Virtual, Augmented and Mixed Reality 2014;267-76. Springer, Cham.
32. Towers A, Field J, Stokes C, et al. A scoping review of the use and application of virtual reality in pre-clinical dental education. Br Dent J 2019;226:358-66.
33. Collaço E, Kira E, Sallaberry LH, et al. Immersion and haptic feedback impacts on dental anesthesia technical skills virtual reality training. J Dent Educ 2021;85:589-98.
34. Sweta VR, Abhinav RP, Ramesh A. Role of Virtual Reality in Pain Perception of Patients Following the Administration of Local Anesthesia. Ann Maxillofac Surg 2019;9:110-3.
35. Crasilneck HB, Jenkins MT, Mccranie EJ. Special indications for hypnosis as a method of anesthesia. J Am Med Assoc 1956;162:1606-8.
36. Moss D, Willmarth E. Hypnosis, anesthesia, pain management, and preparation for medical procedures. Ann Palliat Med 2019;8:498-503.
37. Facco E, Bacci C, Zanette G. Hypnosis as sole anesthesia for oral surgery: The egg of Columbus. J Am Dent Assoc 2021;152:756-62.
38. Malamed SF. Buffering local anesthetics in dentistry. Pulse 2011;44:8-9.
39. Goodchild JH, Donaldson M. Novel Direct Injection Chairside Buffering Technique for Local Anesthetic Use in Dentistry. Compend Contin Educ Dent 2019;40: e1-e10.
40. Malamed SF, Falkel M. Advances in local anesthetics: pH buffering and dissolved CO2. Dent Today 2012;31:88-93; quiz 94-5.
41. Tirupathi SP, Rajasekhar S. Buffered versus unbuffered local anesthesia for inferior alveolar nerve block injections in children: a systematic review. J Dent Anesth Pain Med 2020;20:271-9.
42. Kattan S, Lee SM, Hersh EV, et al. Do buffered local anesthetics provide more successful anesthesia than nonbuffered solutions in patients with pulpally involved teeth requiring dental therapy?: A systematic review. J Am Dent Assoc 2019;150:165-77.
43. Friedman MJ, Hochman MN. A 21st century computerized injection system for local pain control. Compend Contin Educ Dent 1997;18:995-1000, 1002-3; quiz 1004.
44. Fowler S, Crowley C, Drum M, et al. Inferior Alveolar Nerve Block Injection Pain Using a Computer-Controlled Local Anesthetic Device (CCLAD): A Prospective, Randomized Study. Anesth Prog 2018;65:231-6.
45. Kwak EJ, Pang NS, Cho JH, et al. Computer-controlled local anesthetic delivery for painless anesthesia: a literature review. J Dent Anesth Pain Med 2016;16:81-8.
46. Melzack R, Katz J. The gate control theory: Reaching for the brain. In: Hadjistavropoulos T, Craig KD (Eds.). Pain: Psychological perspectives. Lawrence Erlbaum Associates Publishers, 2004:13-34.
47. Dickenson AH. Gate control theory of pain stands the test of time. Br J Anaesth 2002;88:755-7.
48. Katz J, Rosenbloom BN. The golden anniversary of Melzack and Wall's gate control theory of pain: Celebrating 50 years of pain research and management. Pain Res Manag 2015;20:285-6..
49. Shaefer JR, Lee SJ, Anderson NK. A Vibration Device to Control Injection Discomfort. Compend Contin Educ Dent 2017;38:e5-8.
50. Shilpapriya M, Jayanthi M, Reddy VN, et al. Effectiveness of new vibration delivery system on pain associated with injection of local anesthesia in children. J Indian Soc Pedod Prev Dent 2015;33:173-6.
51. Brady M, Woo D, Cuny E, et al. Adoption of IRT: An Instrument Retraction Technique in Local Anesthesia Delivery. J Anesth Clin Res 2021;12:986.
52. Fa BA, Gupta S, Bhattacharrya M. Operator Preference of Retraction Method during anesthesia delivery. Stoma Edu J 2016;3:10-5.
53. Fa BA, Cuny E. Preliminary Evidence Supports Modification of Retraction Technique to Prevent Needlestick Injuries. Anesth Prog 2016;63:192-6.
54. Ching D, Finkelman M, Loo CY. Effect of the DentalVibe injection system on pain during local anesthesia injections in adolescent patients. Pediatr Dent 2014;36:51-5.
55. Dak-Albab R, Al-Monaqel MB, Koshha R, et al. A comparison between the effectiveness of vibration with Dentalvibe and benzocaine gel in relieving pain associated with mandibular injection: a randomized clinical trial.

Anaesth Pain & Intensive Care 2016;20:43-9.
56. Askar H, Misch J, Chen Z, et al. Capnography monitoring in procedural intravenous sedation: a systematic review and meta-analysis. Clin Oral Investig 2020;24:3761-70.

doi: 10.21037/joma-21-9
Cite this article as: Fa BA, Reid L. Evolution of dental anesthesia: a narrative review of innovations in preclinical teaching and clinical care. J Oral Maxillofac Anesth 2022.