# Evaluation of Effectiveness of the "Local Anesthesia" Educational Module Groups of Students with Varying Levels of Professional Training

Vasil'ev Yu.L.[1]*, Dydykin S.S.[1], Rabinovich S.A.[2], Marina Kapitonova[3], Sergey Gupalo[4], Kytko O.V.[1]

1. Sechenov university, Clinical Medicine Institute, operative surgery and topographic anatomy department, Moscow, Russia.
2. A.I. Evdokimov Moscow State University of Medicine and Dentistry (MSUMD), Department of dental anesthesiology, Moscow, Russia.
3. Universiti Malaysia Sarawak, Department of Basic Medical Sciences, Faculty of Medicine and Health Sciences, Kota Samarahan, Sarawak, Malaysia.
4. Universiti Sultan Zainal Abidin, Faculty of Medicine, Kuala Terengganu, Terengganu, Malaysia.

**Abstract**

Today, the lack of realistic practice among students leads to many mistakes in practice and fear of the future work. The purpose of this work is to study the effectiveness of applying the newly developed educational module in the discipline "local anesthesia in dentistry" in groups of students with different levels of professional training. In this study, a new concept of learning to perform inferior alveolar nerve block (IANB) was tested. The study involved 240 people (80 in each of the 3 groups – students, residents and dentists, then the groups were divided into equal subgroups – 40 people in each). After the briefing, the subgroups started studying the program: subgroup 1 of each group followed the Skull-Phantom-Simulator (PSS) training module, where the training format included skill-building exercises on the skull followed by phantom practice and an exam on a hybrid simulator. Subgroup 2 of each group used the Phantom-Skull-Simulator (PSF) training module, where the training format included skill-building exercises on a semi-anthropomorphic phantom followed by a correction practice on the skull and an exam on a hybrid simulator. The study showed the effectiveness of using the Phantom-Skull-Simulator (PSS) system for educational purposes for residents (the efficiency of the procedure was increased by 90%), both types of simulations are equally suitable for training doctors, and the Skull-Phantom-Simulator (SPS) system is more suitable for teaching students – the efficiency increased by 83.36%.

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## Introduction

The quality evaluation criteria of specialist training require modern educational technologies. Simulation techniques can model not only an individual nosological condition but provide the student's integration into the nearly real clinical conditions.

Educational standards stipulate that undergraduate students cannot be involved in independent clinical activity, while constant training on standardized patients can lead to learning situations which are far from real clinical practice.

***Corresponding author:***
Assoc. Prof. Vasil'ev Yuriy
Sechenov university, Clinical Medicine Institute,
operative surgery and topographic anatomy department,
Moscow, Russia.
E-mail: y_vasiliev@list.ru

The complexity of the educational process in the discipline "local anesthesia in dentistry" largely results from the lack of simulators with an integrated assessment scale and feedback. Traditionally, a cadaver preparation is the gold standard of the educational model. Thiel embalmed cadavers are most suitable for educational purposes, including the training in maxillofacial anesthesia due to the preserved mobility of the temporomandibular joint, tissue elasticity and relatively good color rendering[1]. Additionally reported the high training efficiency of Thiel-embalmed cadavers stressing the students' good tolerance of the environment where they work with the cadavers, the convenience and the close to natural condition of the cadavers[2]. The authors indicated that the preservation of the periodontal complex allows hands-on training in teeth extraction.

The effectiveness of simulation training for students performing anesthesia for the first

time[3]. Thus, the local anesthesia (LA) simulation model was used in a facilitated small group setting before dental students administered an inferior alveolar nerve block (IANB) for the first time. The results of this pilot study suggest that using a local anesthesia simulation model may be beneficial in increasing a dental student's level of comfort prior to administering local anesthesia for the first time.

In 2006, a survey was conducted at dental schools and faculties of medical universities to assess the teaching methods of local anesthesia[4]. This survey revealed that, depending on the region and available resources, the training methods differ. For example, in most schools, the theoretical training begins in the fifth semester (41%) and six months before skill building (43%). In 37% of dental schools, students use phantoms and simulators to manage anesthesia methods. As a rule, in 61% of cases the first injection is performed in fellow students under the supervision of a professor. The number of injections under the supervision of a professor usually depends on the individual abilities of a student (41%). Ten percent of schools require the approval of the ethics committee for skill-building exercises on classmates. The survey did indicate that in all dental programs, the training in mandibular area anesthesia is mandatory. Most schools also include training in infiltration anesthesia of the maxilla (98%) and mandible (92%) in addition to block methods (57%).

In a later study from Turkey revealed that students begin to study the theoretical part of their local anesthesia programs in the fifth semester[5]. At most university departments, the skill building exercises normally begin in the sixth semester following the six-month theoretical training. The 82% of the first injections in people are usually done in fellow students under the supervision of a maxillofacial surgeon. Unlike Europe, Turkey did not require the ethics committee approval to perform injections on the fellow students. The authors demonstrate high satisfaction with the educational process: 73% of the departments are satisfied with their current level of training and do not plan any changes.

A survey provided data in the United States[6]. These authors note that three main pedagogical models are followed: didactic training based on textbooks and lectures, injections in a fellow student and the use of anatomical models. However, these authors did not evaluate the impact of these methods on the local anesthesia effectiveness, patient satisfaction, and student confidence in their local anesthesia skills. The mean quality evaluation score of the examined articles was 62% (range 44-83%) for the observational studies and 56% (range 47-63%) for the intervention studies. The experimental and observational studies provided some idea of the modern training techniques effectiveness; however, they had numerous methodological inconsistencies. The inconsistent data made it difficult to develop fully informed curriculum recommendations based on the literature.

In another study a specialized questionnaire, which was sent to students via e-mail, was developed to identify how the Dutch dental students evaluate the quality of local anesthesia training[7]. The authors analyzed 397 completed questionnaires. In all three dental schools, the theoretical aspects of local anesthesia were delivered at the third semester. The hands-on skill building began at the fourth or fifth semester. The preclinical training model (dental phantom) was used by 15% of the students in Amsterdam, 20% of the students in Nijmegen and 35% of the students in Groningen. 24-74% of the students reported that they did not feel prepared when they administered their first injection to a fellow student (91-98% of first injection cases). 35-52% of the students said they would also like to receive intraligamentary anesthesia training in the dentistry program. They proposed curriculum changes, especially the introduction of preclinical training models (29%, 55% and 56% for Groningen, Nijmegen and Amsterdam, respectively).

The literature poorly covers the topic of simulation techniques used in the training process. One can find some data on the role of video training using YouTube. Assessed user activity for 40 video clips on tooth anatomy and local anesthesia methods, which were uploaded to the portal and were available for eighteen months from March 2012 to September 2013[8]. The video on local anesthesia and anatomy was watched over 71,000 and 58,000 times, respectively. This study demonstrates that YouTube can be used as an additional tool to complement dental education, as it is easily accessible on the Internet. The effectiveness of a classic lecture course and a manual simulation

course and revealed that situation modeling and the possibility to combine theoretical knowledge with tactile practices can increase the overall effectiveness of the training process[9].

It was shown that students who used the mobile simulator in addition to their education in augmented reality carried out anesthetic procedures for IANB in a shorter period of time and had greater success than the students who used only the conventional educational methods[10].

The phantoms and simulators with varying degrees of anthropomorphism can significantly increase both the quality of training programs and the students' motivation. The preclinical simulation course influence on local anesthesia effectiveness in practice[11]. The study revealed that the high marks on the simulation course and the success rate of anesthesia on mannequin models did not correlate with success *in vivo*. Since local anesthesia training models are a valuable didactic addition, the training should focus on the real-life situation.

Local anesthesia training models are a valuable didactic complement, the focus of the training should be on to the actual real-life situation[12]. Chair side feedback should be offered to the students using one of the presented evaluation methods.

An important aspect of effective local anesthesia in dentistry is a detailed study of the features of the anatomical structure of the mandible where the nerve block methods (such as mental nerve and IAN) of which are known for their difficulties in performing by young specialists but use of periodontal injections can be more easy and effective in focus of technique features[13,14].

The lack of objective methods to assess the effectiveness of local anesthesia mastering during training reveals a number of problems associated with both the low quality of the training and the fear development in students resulting in multiple technical errors following the transition from simulation training to the clinical practice.

**The objective of this study** was to evaluate the effectiveness of the developed educational module in the discipline "Local Anesthesia in Dentistry" in groups of students with varying levels of professional training based on modified technique of inferior alveolar nerve block anesthesia based on the individual anatomical measurements.

## Materials and methods

Our educational modules were based on anatomical studies performed at Sechenov University (operative surgery and topographic anatomy department)

The anatomical study was completed between December 2018 and April 2019 and included 240 adult (20 to 45 years) cadaveric mandibles with the preserved (saved) height of the alveolar process in the distal part.

Linear measurements based on points C1-C2; M(c1-c2); C1-A; R-A; R- M were completed using calipers and recorded in cm. The nomenclature used was based on Latin terms denoting anatomical formations according to International anatomical terminology.

The minimum and maximum values, M and standard deviation were determined. We made anatomical and mathematical modeling algorithm for the mandible foramen.

In order to complete the anatomical and mathematical modeling the following dimensions were determined:

1) Anatomical width, distance $C_1$-$C_2$ : distance between condylar process and coronoid process;
2) Point M($c_1$-$c_2$) was determined as the projection point on the area of the middle of the edge of the zygomatic arch, which clinically corresponds to the cavity in the area between front-upper part of condylar process and inferior surface of zygomatic arch;
3) Working anatomical height $C_1$-A: distance between the condylar process and mandibular angle;

The projection point (R) on the front surface of ramus of the mandible was determined. It is higher than the retromolar area of the mandible.

4) Oblique bottom distance between the mandibular angle (A) and projection point of the retromolar area of mandible (R);
5) Oblique top distance between R and M($c_1$-$c_2$).

The purpose of the education part of the study was to evaluate the effectiveness of training on phantoms and simulators in an

attempt to identify an efficient method of teaching mandibular local anesthesia.

We recruited three groups of participants who were classified according to medical practice duration. The study was done in 2017-2018 at the Dental Disease Propedeutic Department of the Russian People's Friendship University, the Therapeutic Dentistry Department, the Russian Medical Academy of Post-Diploma Training, the Simulation Center, the Privolzhsky Research Medical University, and S.T.I. Dent Training Center). No gender-related classification of the participants was done. The base line data is presented in **Table 1**.

| Group designation | Number of participants |
|---|---|
| Group 1 – 2nd year students | 80 |
| Group 2 – residents | 80 |
| Group 3 – dentists with 5-8 year experience | 80 |
| Total | 240 |

**Table 1.** The distribution of the participants in the pilot study of the local anesthesia training module.

We proposed a training concept based on an integrative approach to the student depending on clinical experience. The study inclusion criterion for dentists was the modified technique of inferior alveolar nerve block anesthesia experience, for the students - good and excellent clinical anatomy of mandible knowledge.

The training modules involved the following stages:

1) Theoretical block: all the participants were provided with a brief overview of the methodology and a slide presentation with 3D models demonstrating the target injection area, adjacent structures, blood supply and innervation.
2) The practical block involved splitting into two groups: group 1 followed the "Skull (Figure 1) – Phantom (Figure 2a; Figure 2b) –Simulator (Figure 3, Figure 4)" training, while group 2 followed the "Phantom-Skull-Simulator" training module.
3) Students were divided into 3 categories

2.1 students (n=80) two courses of 40 participants each;
2.2 residents (n=80) two courses of 40 participants each;
2.3 dentists (n=80) two courses of 40 participants each.

The training effectiveness evaluation was supervised by the professor and involved specialized software.

**Figure 1.** Manual skill training with a skull without soft tissues.


**Figure 2A.** Manual skill training on non-anthropomorthic phantoms with an imitated gum: correct task performance.

The study involved 80 second-year dentistry students, 80 residents and 80 dentists with 5-8-year experience who participated in the local anesthesia modified technique training program.

Initially, the students were provided with a brief lecture-presentation that explained the goals and objectives of local anesthesia, demonstrated the necessary tools and safety measures, including an aspiration test, and how to interpret

the results. The lecture was followed by a demonstration using photos and videos of modified mandibular anesthesia techniques on a skull and on a patient.


**Figure 2B.** Manual skill training on non-anthropomorthic phantoms with an imitated gum: incorrect task performance.

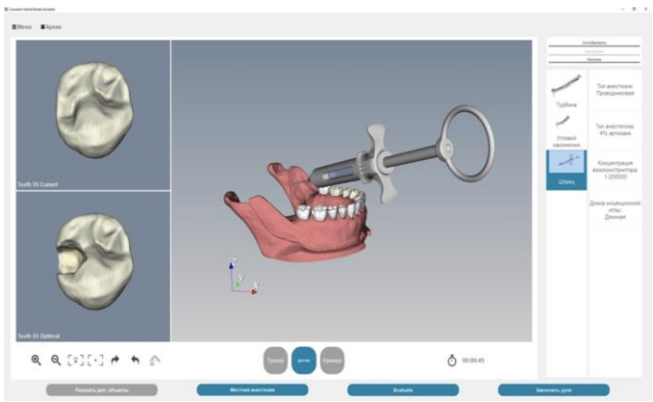

**Figure 3.** The image of hybrid simulator monitors during anesthesia manual skills training.

**Figure 4.** Head of the hybrid simulator during anesthesia manual skills training.

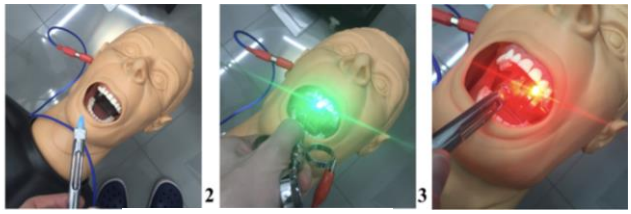


**Figure 5.** Manual skill training exercise "Injection into the target point" on a feedback simulator: 1 – the simulator prior an injection, 2 – a successful injection, 3 – unsuccessful injection.

The study participants were then divided into 2 subgroups to implement this methodology in the conditions of simulation training. The groups were to be trained in dental local anesthesia methods followed by an intermediate skill correction stage and a hybrid simulator exam.

Subgroup 1 followed the Skull-Phantom-Simulator (PSF) educational module, where the training format involved skill building exercises on a skull followed by phantom practice and an exam on a hybrid simulator. Subgroup 2 used the Phantom-Skull-Simulator (PSF) educational module, where the training format involved skill building exercises on a phantom followed by correction practice on a skull and an exam on a hybrid simulator. The assessment involved a 2-point scale with "0" for unsuccessful and "1" for successful accomplishment of the exam assignment.

The study was approved by Sechenov University Institutional Review Board (Protocol № 06-17 of July 12, 2017). The study findings statistics was calculated with MicrosoftOfficeExcel 2016 provided the variable distribution was normal.

## Results

According to the anatomical research we got next results. To search for the projection of the mandibular foramen we offer the following schemes which can be performed both with and without immersing the thumb into the oral cavity. The algorithm of performing modified mandibular anesthesia on the right is given in the.

Unique aspect of this technique emplies the position of the doctor both in front of the patient and behind, when performing anesthesia on the left side, provided that the doctor is right-handed. The essence of the technique is to search for the middle of the base of the triangle formed between the points of reference: the

angle of the mandible, the retro-molar space and the groove formed by the space under the zygomatic arch and the mandibular notch.

The preparatory phase allowed us to incorporate the results of anatomical research into educational modules.

In the group of 2nd year Dentistry students, we compared the parameters of the Skull-Phantom-Simulator (PSU) educational module between the training and the exam to identify the significance for the parameters "Injection into the target point" (Figure 5) (Mann-Whitney U-test = 0.02 at P ≤0.05), "Aspiration test" (Mann-Whitney U-test = 0.000 at P≤0.05) and "Finger position" (Mann-Whitney U-test = 0.02 at P≤0.05).

The Phantom-Skull-Simulator (PSF) training module evaluation revealed insignificant difference for "Injection into the target point" parameter (Mann-Whitney U-test = 0.12 at P≤0.05). The difference for the "Aspiration test" (Mann-Whitney U-test = 0.004 at P≤0.05) and the "Finger positioning" (the Mann-Whitney U-test = 0.03 at P≤0.05) was significant.

Thus, the parameter frequency for the training module demonstrated the efficiency of "Skull-Phantom-Simulator" for the second-year students (**Table 2**).

| The «Skull-Phantom-Simulator» module | | | |
|---|---|---|---|
| Parameter | Comparison between | Test | Significance (p) |
| Injection into the target point | Training & Exam | Mann-Whitney U-test | 0.02* |
| Aspiration test | Training & Exam | | 0.000* |
| Finger position | Training & Exam | | 0.02* |
| The «Phantom-Skull-Simulator» module | | | |
| Parameter | Comparison between | Test | Significance (p) |
| Injection into the target point | Training & Exam | Mann-Whitney U-test | 0.12 |
| Aspiration test | Training & Exam | | 0.04* |
| Finger positioning | Training & Exam | | 0.03* |

* - difference is significant (p≤0.05)

**Table 2.** The parameter comparison between the training and the exam in the various training trajectory groups in 2nd year students.

The higher effectiveness of the "Skull-Phantom-Simulator" educational module can be explained both by better human anatomy knowledge survival, which is indicated by the higher success rate in finger positioning skill mastering on the basic anatomical reference points, and the lack of oral cavity manipulation experience without anatomical reference points.

The intermediate stage of the technique mastering on a hybrid simulator allows the transfer of the bone structures palpation skills to an artificial skin on the lower third of the simulator's "face" and synchronization of the dominant hand movement in an isolated space.

In this regard, we recommend inclusion of the "local anesthesia" block into the training following the method based on the patient's anatomy and constitution since the method demonstrated higher efficiency for the students' specific knowledge and skills level.

The residents in the "Skull-Phantom-Simulator" educational module demonstrated significant difference in the "Aspiration test" (Mann-Whitney U-test = 0.04 at P≤0.05) and in the Finger positioning" to identify to reveal the mandibular foramen projection on the branch (Mann-Whitney U-test = 0.002 at P≤0.05). The "Injection into the target point" parameter revealed no significant difference. (Mann-Whitney U-test = 0.11 at P≤0.05)

In contrast to the previous module, the "Phantom-Skull-Simulator" educational module evaluates the significance of the "Injection into the target point" (Mann-Whitney U-test = 0.05 at P≤0.05) and the "Finger positioning" in the identification of an individual target point (U-Mann-Whitney criterion = 0.01 for p≤0.05), however, the "Aspiration test" revealed no significant difference (Mann-Whitney U-test = 1.00 for p≤0.05).

The resident statistics demonstrates the higher efficiency of the "Phantom-Skull-Simulator" module (**table 3**)

| The «Skull-Phantom-Simulator» module | | | |
|---|---|---|---|
| Parameter | Comparison between | Test | Significance (p) |
| Injection into the target point | Training & Exam | Mann-Whitney U-test | 0,11 |
| Aspiration test | Training & Exam | | 0,04* |
| Finger positioning | Training & Exam | | 0,002* |
| The «Phantom-Skull-Simulator» module | | | |
| Parameter | Comparison between | Test | Significance (p) |
| Injection into the target point | Training & Exam | Mann-Whitney U-test | 0,05* |
| Aspiration test | Training & Exam | | 1,00 |
| Finger positioning | Training & Exam | | 0.01* |

** - difference is significant (p≤0.05)*

**Table 3.** The parameter comparison between the training and the exam in the various training trajectory groups in residents.

This can be explained by a developed skill of working in the oral cavity, as well as tactile perception of target points by palpation. No significant difference in the results of the aspiration test evaluation is explained by the same result in the parameter frequency.

The corrective stage of skill building on the skull allows the detailed analysis of the finger positioning algorithm and the probable syringe

directions towards the target point at the mandibular nerve and mandibular foramen.

The dentists demonstrated a significant difference in the "Aspiration Test" parameter, while other parameters revealed the same frequency in the comparison of performance parameters in the training and exam of the "Skull-Phantom-Simulator" and the "Phantom-Skull-Simulator" training modules (**Table 4**)

| The «Skull-Phantom-Simulator» module | | | |
|---|---|---|---|
| Parameter | Comparison between | Test | Significance (p) |
| Injection into the target point | Training & Exam | Mann-Whitney U-test | 0.13 |
| Aspiration test | Training & Exam | | 0.02* |
| Finger positioning | Training & Exam | | 0.39 |
| The «Phantom-Skull-Simulator» module | | | |
| Parameter | Comparison between | Test | Significance (p) |
| Injection into the target point | Training & Exam | Mann-Whitney U-test | 0.49 |
| Aspiration test | Training & Exam | | 0.000 |
| Finger positioning | Training & Exam | | 0.07 |

** - difference is significant (p≤0.05)*

**Table 4.** The parameter comparison between the training and the exam in the various training modules groups in residents.

## Discussion

One should note the effectiveness of the developed training principle, which allows combining the stages of training, calibration and examination, depending on the target audience degree of preparedness and the presence or absence of clinical experience.

The analysis of the "Phantom-Skull-Simulator" training module revealed that the compared groups significantly differ both in individual parameters and at training and an exam.

An important indicator is the pronounced effectiveness of the skill building exercises both on a skull and on a phantom with imitation of soft tissues into the educational trajectory. Knowledge of and control for the anatomical features during inferior alveolar block (mandibular anesthesia) increase the safety of the method.

The "Skull-Phantom-Simulator" training module revealed higher efficiency the group of students, who demonstrated 33.34%, 43.34% and 20% better results for the "Injection into the target point", the "Aspiration test" and the "Fingers positioning" blocks, respectively compared to the "Phantom-Skull-Simulator" module. This tendency can be explained both by better human anatomy knowledge, which is indicated by the higher success rate in finger positioning skill mastering on the basic anatomical reference points, and the lack of oral cavity manipulation experience without anatomical reference points.

In the group of residents, the "Phantom-Skull-Simulator" module demonstrated higher effectiveness, which was 16.66% higher in the "Injection into the target point" task and in the "Aspiration test" task. In the "Finger positioning" block, the results were 23.33% better than the "Phantom-Skull-Simulator" module.

Such results can be explained by a developed skill of working in the oral cavity, as well as by the tactile perception of target points by palpation.

The group of dentists in the "Skull-Phantom-Simulator" module improved the quality of injection into the target point (6.66% more effective) and the aspiration test (6.67% more effective). These results from a vivid training model, where at the training stage, the dentists could synchronize the movement relative to bone structures. The fingers positioning control based on extra oral reference points demonstrated better results (13.34% more effective) in the "Phantom-Skull-Simulator" module, which results from integration into a familiar environment with a simulation patient. The intermediate stage with a skull allows clarification of the main points' projection on the soft tissues, as well as identification of the injection needle direction relative to the injection target point and evaluation of the insertion degree relative to the mandibular branch width.

## Conclusions

1) Developed modified technique of inferior alveolar nerve block anesthesia on the mandible was is based on the anatomical measurements and shows good results in the educational process, regardless of the level of initial training of the student.
2) We demonstrated the effectiveness of the triad educational trajectory in the discipline "local anesthesia in dentistry" for both graduate and postdiploma students. In general, the evaluation of students' manual skill in the mandibular local conduction anesthesia (finger positioning, an aspiration test and injection in the target point) revealed the priority of the "Skull-Phantom-Simulator" module (83.36%), which is explained by a

lack of oral cavity manipulation skills.

3) In resident training, the "Phantom-Skull-Simulator" trajectory is preferable (90% more effective). This trajectory includes an intermediate link in the form of a bone preparation, which is used for the skill calibration.
4) In postdiploma training, both trajectories are recommended. The introduction of a three-stage trajectory in the dentist postdiploma training revealed the need for an integrative approach, taking into account the manual skill. In the search for anatomical reference points, the first step involves the familiar environment of a phantom, and the skill verification and calibration involve the manipulation with a skull.

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## Declaration of Interest

The authors report no conflict of interest.

## References

1. Lone M, McKenna JP, Balta JY. Assessment of Thiel-Embalmed Cadavers as a Teaching Tool for Oral Anatomy and Local Anesthesia. J Dent Educ. 2017;81(4):420-426. doi: 10.21815/JDE.016.012.
2. Hanson C, Wilkinson T, Macluskey M. Do dental undergraduates think that Thiel-embalmed cadavers are a more realistic model for teaching exodontia? Eur J Dent Educ. 2018;22(1): e14-e18. doi: 10.1111/eje.12250.
3. Corrêa CG, Machado MAAM, Ranzini E, Tori R, Nunes FLS. Virtual Reality simulator for dental anesthesia training in the inferior alveolar nerve block. J Appl Oral Sci. 2017;25(4):357-366. doi: 10.1590/1678-7757-2016-0386
4. Brand HS, Tan LL, van der Spek SJ, Baart JA. European dental students' opinions on their local anaesthesia education. Eur J Dent Educ. 2011;15(1):47-52. doi: 10.1111/j.1600-0579.2010.00633.x.
5. Tomruk CÖ, Oktay İ, Sençift K. 2013. A survey of local anesthesia education in Turkish dental schools. J Dent Educ. 2013;77(3):348-50.
6. Kary AL, Gomez J, Raffaelli SD, Levine MH. Preclinical local anesthesia education in dental schools: a systematic review. J Dent Educ. 2018;82(10):1059-1064. doi: 10.21815/JDE.018.106.
7. Brand HS, Kuin D, Baart JA. A survey of local anaesthesia education in European dental schools. Eur J Dent Educ. 2008;12(2):85-8. doi: 10.1111/j.1600-0579.2008.00505.x.
8. Mukhopadhyay S, Kruger E, Tennant M. YouTube: a new way of supplementing traditional methods in dental education. J Dent Educ. 2014;78(11):1568-71.
9. Marei HF, Al-Jandan BA. Simulation-based local anaesthesia teaching enhances learning outcomes. Eur J Dent Educ. 2013;17(1):e44-8. doi: 10.1111/j.1600-0579.2012.00760.x.
10. Mladenovic R., Pereira LA, Mladenovic K, Videnovic N, Bukumiric Z, Mladenovic J. Effectiveness of Augmented Reality Mobile Simulator in Teaching Local Anesthesia of Inferior Alveolar Nerve Block. J Dent Educ. 2019; 83(4):423-428. doi: 10.21815/JDE.019.050.
11. Knipfer C, Rohde M, Oetter N, Muench T, Kesting MR, Stelzle F. Local anaesthesia training for undergraduate students - how big is the step from model to man? BMC Med Educ. 2018; 14;18(1):308. doi: 10.1186/s12909-018-1389-6
12. Plessas A. Computerized virtual reality simulation in preclinical dentistry: can a computerized simulator replace the conventional phantom heads and human instruction? Simul Healthc. 2017 Oct;12(5):332-338. doi: 10.1097/SIH.0000000000000250.
13. Almudares, M.F., Al-Seghairi, M.M. Mental Foramen / Canal / and Mental Block Anesthesia. Journal of International Dental and Medical Research. 2009; 2: 37-39.
14. Tekin U., Ersin N., Onçağ O., Bent B., Menderes M., Koçanal B. Comparison of inferior alveolar nerve block and intraligamentary anesthesia on the discomfort of children. Journal of International Dental and Medical Research, 2012;5;143-148.