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# Effectiveness of Virtual Reality in Local Anesthesia Practice Among a Dental Student's Aspect

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***Abstract:-*** This study aimed to develop VR teaching materials to enhance visualization skills in preclinical dental education, specifically for the inferior alveolar nerve block technique. Using the Oculus Quest II, a VR simulation program was created and tested on 3rd and 4th-year dental students at Suranaree University of Technology. Participants first received 30 minutes of instruction followed by a pre-test, then engaged with the VR program, and completed a post-test. A questionnaire measured program satisfaction, which was validated by experts and had a reliability score of 0.69. The average satisfaction score was 4.3, and post-test scores significantly improved over pre-test scores ($p<0.05$). These results suggest that the VR program enhances learning experiences and procedural skills, indicating its potential benefit for dental education.

***Keywords****:* Local anesthesia, Simulation, Virtual reality, Dental student.

## 1. Introduction

After the widespread impact of the COVID-19 pandemic, the learning landscape for dental students has undergone significant changes, with technology playing an increasingly crucial role in the educational process. The convergence of augmented reality (AR), virtual reality (VR), and mixed reality (MR) is a notable aspect of immersive technology[1]. Moreover, the use of technology in dental education has increased, with a significant emphasis on its application in restorative dentistry [2]. This trend indicates a potential transformation where immersive technologies become an integral part of daily life. In studies conducted in Thailand, it has been observed that the widespread adoption of these technologies in education is relatively limited. Moreover, there is a notable absence of instructional media for training in administering nerve block anesthesia, such as the Inferior Alveolar Nerve Block (IANB)[3].

Local anesthesia procedures, such as the inferior alveolar nerve block (IANB), are crucial in dentistry for pain management prior to other dental treatments. However, they have a high failure rate of approximately 20-25%. Contributing factors to this include the difficulty in identifying anatomical landmarks, a lack of experience or knowledge in procedural techniques [4].

In 2021, Zafar S. *et al*. conducted a study aimed at examining the perception of using virtual reality simulation programs for local anesthesia injections in pediatric dentistry. This study involved 71 students, who completed self-administered questionnaires both before and after using the virtual reality simulation program for local anesthesia injections. The results indicated that most participants believed the program could enhance their ability to perform local anesthesia injections, increase their learning experience, and more than half agreed that the program helped improve their understanding of the relevant anatomical aspects involved in local anesthesia injections [5].

Therefore, this study aims to evaluate the effectiveness and satisfaction of utilizing Virtual Reality (VR) simulation programs as part of the teaching and learning process for local anesthesia techniques, specifically focusing on the IANB procedure.

## 2. Materials and Methods

### A. Participants

The research team conducted an experiment involving third- and fourth-year preclinical dental students and sixth-year clinical dental students. The 52 preclinical dental students were divided into two groups based on their year of study. The first group consisted of 23 third-year dental students who had not previously experienced traditional training methods for local anesthesia injections on a manikin model. The second group comprised 29 fourth-year dental students who had undergone traditional training methods for local anesthesia injections on a manikin model (Figure 1).

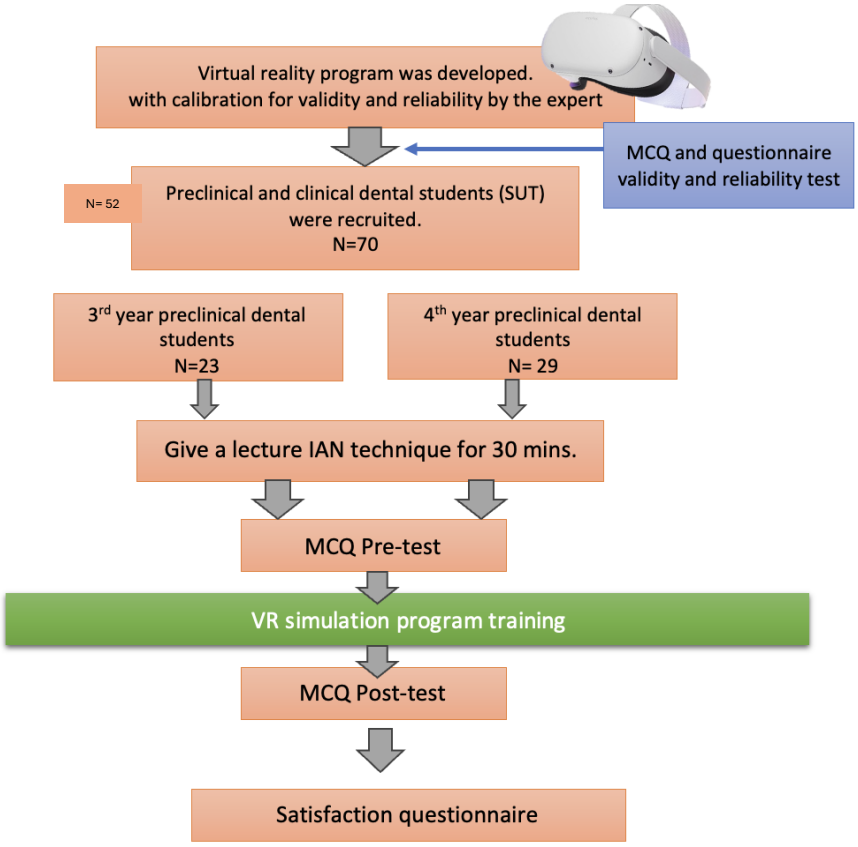


**Figure 1 shows the protocol for virtual reality conducted in dental students.**

### B. Study design.

Each group received basic knowledge training through a 30-minute lecture on the technique of the Inferior Alveolar Nerve Block injection. Following the lecture, the students took a pre-test using a multiple-choice questionnaire to assess their knowledge, which took about 10 minutes. After the pre-test, the students practiced local anesthesia injections using the virtual reality simulation program (Figure 2). Upon completing the practice session, they took the same multiple-choice questionnaire as a post-test to measure their knowledge after the training. The pre- and post-test scores of both groups were collected for further data analysis.

Additionally, the satisfaction levels regarding the use of the virtual reality simulation program for local anesthesia injections were surveyed among the participants. After the practice session, the students completed a satisfaction survey about their experience with the virtual reality simulation program (5= Strongly agreed to 0= Strongly disagreed). The collected data from these surveys were also analyzed.


**Figure 2 shows the virtual reality simulation program for local anesthesia injections.**

**Table 1: The satisfaction survey questionnaire for the Virtual Reality Simulation Program for Local Anesthesia Injection.**

| | |
|---|---|
| Usability | |
| 1 | Is this kind of VR simulator useful in dental education? |
| 2 | Could such VR simulator be useful as a distance learning tool in general and in special conditions? |
| 3 | Are you satisfied with the ease of use of the VR simulator? |
| 4 | Does the use of VR as an adjunct to conventional study improve the knowledge and skills for local anesthesia injection? |
| 5 | Do you think that using VR for learning is better than the conventional study? |
| Knowledge improvement | |
| 6 | Did the VR simulator help to better understand the reference points for IANB anesthesia? |
| 7 | Did the VR simulation for applying local anesthesia help me get to know the anatomical structures of the face and jaws well? |
| 8 | Does the use of VR simulator help to locate the area of inferior alveolar nerve anesthetized? |
| Skill development | |
| 9 | Does the use of VR simulator to local anesthetics injection help to reduce excitement and improve confidence of local anesthesia administration? |
| 10 | Does the use of VR simulator to local anesthetics injection to reduce errors of local anesthesia administration? |
| 11 | Does it easily localize the puncture site? |
| 12 | Did the VR simulation for applying local anesthesia help to visualize the anatomical involvement while performing local anesthesia administration? |

### C. Data analysis

The data analysis followed a quantitative research approach utilizing the SPSS version 29 software to perform statistical analysis. The primary objective was to compare the scores between the pre-test and post-test on local anesthesia injection techniques after using the virtual simulation program. Descriptive statistics were employed to stultification questionaries. Additionally, paired t-tests were used to compare the mean scores before and after the training within each group to determine statistical significance, with $p<0.05$. Independent t-tests were also used to compare the pre-test scores between different groups to assess statistical significance, with a threshold of $p<0.05$ indicating statistical significance.

## 3. Results

### A. Demographic data

The study included 3rd and 4th-year preclinical dental students. Out of the 80 eligible students, 52 (65%) willingly participated in the experiment. The demographics are as follows in table 1.

**Table 1 shows the demographic data of the participants.**

| | total (n=52) | 3rd year dental students (n=23) | 4th year dental students (n=29) |
|---|---|---|---|
| **sex** | | | |
| Male, N (%) | 21 (40.38) | 11 (47.83) | 10 (34.48) |
| Female, N (%) | 29 (55.77) | 10 (43.48) | 19 (65.52) |
| Others, N (%) | 2 (3.8) | 2 (8.69) | 0 (0) |
| **Mean age,** | 22.58 +/- 2.17 | 21.45 +/- 1.87 | 22.21 +/- 1.80 |
| (min-max) | (20-28) | (20-27) | (21-28) |
| **Glasses** | | | |
| Glasses, N (%) | 35 (67.30) | 17 (73.91) | 18 (62.07) |
| No glasses, N (%) | 17 (32.69) | 6 (26.09) | 11 (37.93) |
| **Dominant hand** | | | |
| Left, N (%) | 2 (3.84) | 1 (4.35) | 1 (3.45) |
| Right, N (%) | 50 (96.15) | 22 (95.65) | 28 (96.55) |

### B. Assessment of validity and reliability of the objective tools.

The content validity of the objective pre and post-test were evaluated using the Index of Item-Objective Congruence (IOC), assessed by five experts. The IOC values ranged from 0.2 to 1.0, with questions scoring below 0.5 revised according to expert recommendations. Reliability testing, conducted on a non-sample population, yielded a KR-20 value of 0.72, indicating that the test possesses adequate reliability. The content validity of the objective test was assessed using the Index of Item-Objective Congruence (IOC), evaluated by five experts. The IOC values ranged from 0.6 to 1.0, indicating that the questions in the questionnaire align well with the research objectives.

The reliability of the questionnaire was assessed by calculating Cronbach's alpha coefficients for 30 sets of questions, divided into 3 categories: Usability, Knowledge development, and Skill development. Conducted on a non-sample population, the reliability analysis yielded Cronbach's alpha values ranging from 0.738 to 0.879, indicating that the satisfaction survey possesses suitable reliability (Table 2).

**Table 2: Reliability Analysis of the Satisfaction Survey for the Virtual Reality Simulation Program for Local Anesthesia Injection.**

| Category | No of question | Cronbach' Alpha |
|---|---|---|
| Usability | 5 | 0.879 |
| Knowledge improvement | 3 | 0.856 |
| Skill development | 4 | 0.738 |
| **Overall reliability** | **Total** | **0.738-0.879** |

### C. The 3rd year and 4th year dental student average pre and post-test scores.

For 3rd-year preclinical dental students, the average pre-test score was 5.65 ± 1.849, while the average post-test score was 8.48 ± 1.780. The mean difference between the pre-training and post-training scores was 2.826 points

which have significant difference between pre and post-test. For 4th-year preclinical dental students, there are also significant difference between pre and post-test scores (table 3).

**Table 3: Average score Pre and Post-test in 3rd and 4th year dental students for Local Anesthesia Injection Training Using the Virtual Reality Simulation Program *(p<0.001)*.**

| Dental Student | MCQ test | Mean score ± SD | Mean difference | P value |
|---|---|---|---|---|
| 3rd Year | Pre-test | 5.65 ±1.85 | 2.826 | 0.000 |
| | Post-test | 8.48±1.78 | | |
| 4th Year | Pre-test | 7.45±1.24 | 2.227 | 0.000 |
| | Post-test | 9.72±0.53 | | |

**D. A comparison the mean difference between conventional combined virtual reality (4th year) and virtual reality group.**

From table 4, the mean difference scores between pre and post-test in 3rd and 4th year dental students was no significance difference between group (table 4).

**Table 4: The mean difference of pre-post -test scores between 3rd and 4th year dental students *(p<0.001)*.**

| Pre and post-test scores | Mean score ± SD | Mean difference | P value |
|---|---|---|---|
| 3rd year dental student | 2.30±1.105 | 0.028 | 0.927 |
| 4th year dental student | 2.27±1.09 | | |

**E. The satisfaction level to virtual reality simulation program.**

For 3rd-year preclinical dental students, usability category (question 1 and 3; the most participants "agreed" score=4, at 45.45%, question 2 and 5; the most participants "strongly agreed" score =5 at 50% and 27.27% respectively, question 4; the most participants "agreed" and "strongly agreed" were equally score at 45.45%). For knowledge improvement category, question 6; the most participants "agreed" score=4, at 40.9%. For skill development category, question 9 and 11; the most participants "strongly agreed" score =5 at 40.9%. The question 10 and 12; the most participants "agreed" score =4 at 50%.

For the 4th-year preclinical dental students, usability category (question 1 to 3; the most participants "agreed" score=4, at 44.83%, 51.72% and 51.72% respectively, question 4; the most participants "strongly agreed" score =5 at 48.28%, question 5; the most participants "neither agreed nor disagreed" at 37.93%). For knowledge improvement category, question 6 and 8; the most participants "agreed" score=4, at equally 41.38%, question 7; the most participants "neither agreed nor disagreed" at 44.83%. For skill development category, question 9; the most participants "strongly agreed" score =5 at 40.9%. The question 10 and 12; the most participants "agreed" score =4 at 50%.

## 4. Discussion

The study aimed to assess the levels of knowledge, attitudes, and behaviors toward the use of a virtual reality (VR) simulation program in teaching local anesthesia injection to preclinical dental students. The findings revealed that the use of the VR simulation program significantly enhanced the learning experience for 3rd and 4th-year dental students.

For the knowledge assessment, the pre-test and post-test scores showed a statistically significant difference *(p<0.001),* with post-test scores being significantly higher than pre-test scores. Additionally, when comparing the test score improvements between the group that had received traditional teaching (4th-year students) alongside the VR simulation and the group that had only the VR simulation (3rd-year students), the difference in average scores was also statistically significant (p<0.001).

Particularly, the 4th-year students, who had prior learned to conventional teaching methods combined with the VR simulation, had higher pre-test scores compared to the 3rd-year students who only used the VR simulation. This aligns with the research of Mladenovic R. *et al.*, which also reported increased average scores following the use of a VR simulation program for local anesthesia injection training [6].

The study also assessed the mean differences in test scores before and after the local anesthesia injection training using the VR simulation program among preclinical students. This comparison was made between two groups: one group received traditional (conventional) teaching alongside the VR simulation program, and the other group received only the VR simulation training. The results indicated that there was no statistically significant difference in the average test score improvements between these two groups ($p>0.05$). The study reported that for teaching the antero-superior alveolar nerve infiltration, dental students who were taught using a combination of three methods (lectures, clinical demonstration, and simulation model) were able to perform the injection in a significantly shorter time on average compared to the group that did not learn with the simulation model [7]. The virtual reality simulation program for local anesthesia injection significantly increased the average knowledge scores and enhanced the understanding of inferior alveolar nerve block among preclinical dental students. The limitation for this study is its inability to provide the tactile sense experienced with real patients or physical models. This study aimed to create a 3D simulation that allows clear visualization of the injection site, offering more detailed study compared to conventional models (Manikins) and real patients. This is particularly important for inferior alveolar nerve block, which requires detailed knowledge of internal anatomical structures such as bones, muscles, and blood vessels. The VR program helps preclinical students gain realistic experience and a comprehensive visual understanding before advancing to clinical practice and working with actual patients.

## 5. Conclusion

In conclusion, the VR simulation program effectively improved students' knowledge and understanding of local anesthesia injection, demonstrating significant pre- to post-test score improvements. Additionally, the satisfaction survey indicated that students found the program useful, contributing positively to their learning experience. However, the study also highlighted that the lack of tactile feedback remains a limitation, suggesting a need for further enhancements in VR technology to provide a more comprehensive learning tool.

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