The effect of virtual reality distraction on pain perception of children aged 7-9 years during anesthesia procedure with the jet injector in dental treatment

El efecto de la distracción de realidad virtual en la percepción del dolor de niños de 7 a 9 años durante el procedimiento de anestesia con inyector de chorro en el tratamiento dental

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Abstract

Background: The success of dental treatment in children is strongly influenced by their cooperative level, so it is necessary to create dental care with minimal pain and a pleasant impression. Pain control in dental treatment is carried out by administering anesthesia but giving anesthesia by injection of a syringe causes pain and needle phobia. Thus, the use of jet injectors and virtual reality distractions can reduce children's pain perception during anesthesia procedures. Objective: This study aims to determine the effect of virtual reality distraction on pain perception in children aged 7-9 years during anesthesia procedures with jet injectors in dental treatment. Methods: This study used a quasi-experimental method with a posttest-only non-equivalent group design. A sample of 30 children with extraction indications was divided into two groups. Group A was treated with virtual reality distraction during the anesthetic procedure with a jet injector, while group B was not treated with virtual reality distraction during the anesthetic procedure with a jet injector. In both groups, pain perception was measured after the anesthetic procedure, utilizing the Wong-Baker faces pain rating scale (WBFPRS). Before the research, calibration, or operator perception equations regarding the use of jet injectors were carried out. Results: There was a difference in pain perception ($p<0.005$) between group A ($\bar{x}$ =3.17) and group B ($\bar{x}$ =5.87). Therefore, virtual reality distraction affected the pain perception of children aged 7-9 years during anesthesia procedures with jet injectors in dental treatment.

Keywords: WBFPRS, behavioral management, tooth extraction, needle-free injection, audiovisual

Resumen

Antecedentes: El éxito del tratamiento odontológico en los niños está fuertemente influenciado por su nivel cooperativo, por lo que es necesario crear una atención odontológica con el mínimo dolor y una impresión agradable. El control del dolor en el tratamiento dental se lleva a cabo mediante la administración de anestesia, pero la administración de anestesia mediante la inyección de una jeringa provoca dolor y fobia a las agujas. Por lo tanto, el uso de inyectores a chorro y distracciones de realidad virtual puede reducir la percepción del dolor de los niños durante los procedimientos de anestesia. Objetivo: Este estudio tiene como objetivo determinar el efecto de la distracción de realidad virtual en la percepción del dolor en niños de 7 a 9 años durante los procedimientos de anestesia con inyectores de chorro en el tratamiento dental. Métodos: Este estudio utilizó un método cuasi-experimental con un diseño de grupo no equivalente de solo post-test. Una muestra de 30 niños con indicaciones de extracción se dividió en dos grupos. El grupo A fue tratado con distracción de realidad virtual durante el procedimiento anestésico con un inyector de chorro, mientras que el grupo B no fue tratado con distracción de realidad virtual durante el procedimiento anestésico con un inyector de chorro. En ambos grupos, la percepción del dolor se midió después del procedimiento anestésico, utilizando la escala de calificación del dolor facial de Wong-Baker (WBFPRS). Previo a la investigación, se realizaron ecuaciones de calibración o percepción del operador respecto al uso de inyectores a chorro. Resultados: Hubo diferencia en la percepción del dolor ($p<0,005$) entre el grupo A ($\bar{x}$= 3,17) y el grupo B ($\bar{x}$ = 5,87). Por lo tanto, la distracción de realidad virtual afectó la percepción del dolor de los niños de 7 a 9 años durante los procedimientos de anestesia con inyectores de chorro en el tratamiento dental.

Palabras clave: WBFPRS, manejo conductual, extracción dental, inyección sin aguja, audiovisual

Introducción

Pain is a multidimensional and complex construction involving sensory, emotional, and cognitive processes. These factors can modulate pain[1-4]. The International Association for the Study of Pain (IASP) asserted that pain is an uncomfortable feeling and emotional experience associated with actual or potential tissue damage[5-7].

Pain perception results from complex interactions between nociceptive stimuli, differences between emotional and cognitive factors, which arise because automatic and control systems mediate them. Negative stimuli can increase pain perception and emotional impact[8-10]. Patients with dental anxiety will feel more pain than patients without dental anxiety[11]. Pain assessment methods are divided into two: unidimensional and multidimensional. Unidimensional measurements are used for acute pain and multidimensional measurements for chronic pain. Examples of unidimensional pain measurements are the visual analog scale (VAS) and the Wong-Baker pain rating scale[12-15].

Face scale (a picture of facial expressions) is the most commonly used method in the pediatric population. The Wong-Baker faces pain rating scale is one of several face scales designed as well as possible for assessing pain in children[6,16]. Children will more easily interpret pain against pictures than numbers because of the development of cognitive abilities that have not been perfect. According to Piaget's theory, children aged 7-11 years are at a turning point in cognitive development, characterized by logical thinking; it means that children begin to be able to solve problems in their minds rather than physically trying things in the real world[9].

In dental procedures, pain control is carried out by administering anesthesia. Although the use of anesthesia aims to reduce pain, the fear associated with needle penetration is often the cause of patient reluctance to go to the dentist[17,18]. In patients with needle phobia, the feeling that arises when the needle is inserted into the syringe then penetrates the oral mucosa is enough to stress them and have a negative effect on their psychology[13]. In dentistry, the local anesthetic injection is the most common cause of fear and anxiety, especially in children and adolescents, because it is associated with pain and discomfort. High anxiety and fear can increase pain perception[19,20].

An injection is a most frequently used way to administer drugs, apart from intraoral. However, injection is an invasive procedure that can cause tissue damage, and the injection procedure itself can be a medium for disease transmission. To minimize the above risks, needle-free injection technologies (NFIT) have been developed. Without using a needle, the injection system (jet injector) is a new method for injecting drugs into skin tissue, subcutaneous tissue, and intramuscular tissue with minimal tissue damage[10,21]. The principle of the jet injector is to utilize a mechanical energy source to generate pressure, which allows anesthetic fluid to penetrate and enter soft tissues[22-26].

Jet injectors have advantages, including not causing skin damage due to needle sticks, inserting drugs quickly, better reproducibility than conventional systems, increasing bioavailability compared to conventional systems, having better drug stability, not causing needle phobia, and using independently more likely to do. In addition to the advantages, jet injectors have several disadvantages, consisting of not simple uses, such as injection syringes, are more expensive than injection syringes, and cannot be used for the intravenous route[10]. Another drawback of jet injectors lies in the size and sound produced when the jet injector is used[2].

To overcome the perception of pain, a distraction method is used. Distraction is a behavioral management technique that successfully reduces pain and stressful behaviors by diverting children's attention from painful stimuli during invasive dental procedures. The distraction method is divided into two methods: active and passive. Active distraction methods are distractions that involve the movement of limbs or the child's participation, such as squeezing a ball and playing games. Meanwhile, passive distraction is a distraction method that does not involve body movements, such as watching movies and listening to songs[1]. Moreover, two distraction methods are often used in dentistry, namely audio and audiovisual. Distraction with audio, for example, is listening to music, audio presentations through headphones, and telling stories, while audiovisuals are like seeing and listening to stories through television, virtual reality, and three-dimensional glasses[3].

Virtual reality is a technology that allows interaction with an environment simulated by a computer[20]. Virtual reality uses technology to form a virtual reality, making patients feel they are in an interactive virtual environment[23]. The use of virtual reality for distraction is an advancement compared to traditional distraction because virtual reality displays a more realistic image through virtual reality devices right in front of the user's eyes. In addition, the use of virtual reality can isolate the patient from the stimulus (audio/visual) in the real world. Virtual reality also combines audio, visual, and kinesthetic sensory modalities, depending on the stimulus given. A person's attention will be significantly reduced and distracted from the real world, with little attention to conditions and processes that occur in the real world, including painful stimuli[18].

Therefore, this study was conducted to determine the effect of the distraction method using virtual reality on pain perception in children aged 7-9 years during anesthesia procedures utilizing jet injectors in dental treatment.

Métodos

The research method used was quasi-experimental, with posttest only non-equivalent group design. The study was conducted at the Soelastri Dental and Oral Hospital (RSGM) Universitas Muhammadiyah Surakarta from February 2020 to March 2020. The research subjects were obtained by screening at SDN Bumi 1 (Elementary school in Surakarta, Indonesia) and Al Adsha Orphanage in accordance with the inclusion and exclusion criteria that had been previously determined.

Inclusion criteria were children aged 7-9 years, children with indications for extraction, children with physical and mental health, children without a history of systemic disease, and children with a Frankl behavior scale of 2-4. Exclusion criteria included children with cardiovascular disease, allergies to anesthetic agents, communication limitations, and visual and hearing impairments. The research subjects used in this study were 30 children, divided into two groups. Group A consisted of 15 subjects treated with virtual reality distraction during the jet injector anesthetic procedure. Meanwhile, group B comprised 15 subjects not treated with virtual reality distraction during the jet injector anesthetic procedure. Virtual reality distraction was done using virtual reality (VR) glasses with the brand VR Box. The film shown was a children's cartoon SpongeBob SquarePants with a duration of three-four minutes. Virtual reality distraction was provided during the anesthetic procedure. Before the anesthetic procedure was performed, the device was first attached to the patient, then removed again after the anesthetic procedure was completed.

The study measured children's pain perception with the Wong-Baker faces pain rating scale after the anesthetic procedure. Anesthesia procedure was carried out with infiltration anesthesia method, utilizing a jet injector with the comfort in the brand (Kore), and the anesthetic materials used were 0.3 mL Lidocaine HCL and epinephrine. The research data were analyzed using a statistical parametric independent t-test.

Pain perception research data were taken using the Wong-Baker faces pain rating scale. The data obtained in this study were pain perception data after the anesthetic procedure using a jet injector. Pain perception data were analyzed using an independent parametric statistical t-test. Before testing using the independent t-test, the data were first tested for normality and homogeneity tests. The data requirements that could be tested using the independent parametric t-test were normally distributed data and had homogeneous variants.

The normality test of the data was carried out using the Shapiro-Wilk normality test to determine whether the data were normally distributed. The reason for using the Shapiro-Wilk normality test was that the sample size was 50. The data is said to be normally distributed if the $p<0.05$.

It should be noted that the the ethical committee approved of the study, and the parents consented to this procedure.

Results and Discussion

The Shapiro-Wilk normality test results from the pain perception data of group A and group B children obtained a value of significance in group A of 0.175 and group B of 0.137. The significance value of the two groups showed $p>0.05$, so it can be concluded that the pain perception data were normally distributed.

A homogeneity test was carried out using Levene's test, an inferential statistic used to assess the equality of variances for a variable calculated for two or more groups. The data can be said to be homogeneous if the significance value is $p<0.05$. The homogeneity test results of Levene's test from the pain perception data of group A and group B children obtained a Levene statistic value of 0.635 and a significance value (p) of 0.432. Thus, it can be denoted that the data on children's pain perception in groups A and B were homogeneous ($p>0.05$).

Table 1. Results of data analysis on pain perception in group A and group B

Independent sample t-test					
	Group	N	Mean	Std. deviation	Sig2. (tailed)
Pain perception	A	15	3.07	2.374	0.002
	B	15	5.87	2.200	

Table 1 presents the data analysis results on the pain perception data of group A and group B. In group A with a sample of 15 children, the mean = 3.17 and SD (Std. deviation) = 2.374. In group B with a sample of 15 children, the results obtained mean = 5.87 and SD (Std. Deviation) = 2.200. The significance value (p) obtained was 0.002. It signifies a significant difference in pain perception between group A and group B.

Administration of anesthetic fluid in dental procedures is aimed at relieving pain during the primary treatment procedure. However, the problem that arises in pediatric patients is that administering the anesthetic itself causes pain. In addition, the local anesthetic injection is one of the most challenging procedures in pediatric dentistry. The fear of needles and the pricking associated with the word injection causes children to experience anxiety[16]. This study used a needle-free injection comfort in soft type as a tool to insert anesthetic fluid to minimize pain in patients. The use of jet injectors causes less pain, reduces risks such as cross-contamination, reduces sharps waste disposal, and has more accurate dose administration[14].

Moreover, measuring a child's pain perception requires an effective measuring device that considers the child's development, the context of pain, and previous pain

experiences. Pain scales that use pictures of faces can provide an object representation of the pain experience for children over four years of age. This type of scale can express a child's pain experience objectively well, before numerical thinking skills, cognitive abilities, or the ability to estimate magnitudes are required for the use of numerical scales. In this study, the researchers used the Wong-Baker faces pain rating scale. This scale uses six serial images of facial expressions, with sex-neutral faces ranging from no pain (smiling face) to unbearable pain (crying face). Children older than or equal to three years of age were instructed to choose which face represented the perception of pain experienced and scored from 0-10. WBFPRS is simple and easy to use and has minimal instructions[5].

Virtual reality (VR) is a sophisticated technological system that allows users to move into the virtual world. This technological system can follow the user's movements to give the user the illusion as if the user is really in a different environment.[12] There are several types of VR devices. In this study, the VR devices used were VR glasses. VR glasses include low-cost VR technology. The advantages of low-cost virtual reality hardware are high-performance systems, which previously were exclusively used by research institutes with ample funds. However, they can now be built and used relatively cheaply, lowering the price to performance ratio that provides benefits for hospitals, educational institutions, museums, and other institutions, whose finances for technology development are limited. In the medical field, VR can show promising results in exposure therapy[17].

The mechanism of pain starts from pain stimuli received by nociceptors. Nociceptors are pain receptors in tissues activated by a painful stimulus. The information is then transduced by the receptor into an electrical signal and transmitted from the periphery to the central nervous system via the axon. Pain pathways in the central nervous system are divided into two parts: ascending and descending pathways. Pain signals are transmitted by nerves to higher regulatory centers via the spinothalamic and spinoreticular areas of the anterolateral spinal cord.

In addition, the anterior cingulate cortex (ACC) is a crucial component of VR mechanisms that mediate pain modulating pathways, such as PAG (periaqueductal gray). By shifting attention from the discomfort of a medical setting to a virtual environment, VR activates the pregenual ACC, a structure known to mediate attentional and emotional processes. The pregenual ACC then activates its downstream target, PAG, which stimulates signaling to stimulate the descending pain modulation system and produce analgesia. The amygdala, the main structure of the limbic system, interacts with the ACC and PAG so that activation of the amygdala can produce inhibition or facilitate the perception of pain. Positive emotions can inhibit the part of the amygdala that facilitates pain and produces analgesia[8].

Further, virtual reality is known to reduce pain, and this effect is called VR analgesia. The subjective assessment of pain reduction due to VR effects is corroborated by functional MRI (magnetic resonance imaging) data, showing decreased increased brain activity in areas that are generally strongly activated by thermal pain stimulation[12].

The effect of VR distraction in decreasing perceived pain and anxiety can be attributed to a number of reasons. The application of VR distraction assumes that pain perception has a large psychological component and that pain attracts a strong attentive response because of the potential threat of damaged tissue associated with the sensation[21]. The redirection (distraction) of this attention manipulates the pain perception, thereby reducing the intensity of pain. Recently, it has also been found that VR changes the way people interpret incoming pain signals and reduces the amount of pain-related brain activity[16,19]. Moreover, it can be concluded that VR engages the conscious attention of the patient, resulting in less pain perception by the patients. By diverting attention from an unpleasant medical setting to a pleasant and absorbing virtual world, while also engaging higher cognitive and emotional centers of the nervous system, VR can markedly diminish a patient's subjective pain experience. In the case of pediatric dentistry, the anxiety-inducing appearance of the dental equipment and the continuous focus of the child on all the details of the procedure that is being carried out, are the most important reasons for stress associated with dental procedures in children[4,14,22].

The advantages of using virtual reality for distraction are that it is easy to use, easier to control treatment, safe for patients, and does not need special instructions. Even more, the use of this technique many times will not reduce its positive effect, and it can be easily used in pediatric patients and with minor size modifications for adults. Moreover, this technique is well accepted between the patient and the patient's care as the most significant advantage[15].

Closing remarks

Based on the research results above, it can be concluded that virtual reality distraction influenced pain perception in children aged 7-9 years during anesthesia procedures with jet injectors in dental treatment. The effect is the level of pain perception in the group treated with virtual reality distraction was lower than the level of pain perception in the untreated group.

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