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Impact of a 360-degree Nature Film in Virtual Reality on Pain During Arteriovenous Fistula Puncture in Patients undergoing Hemodialysis: A Pre- and Post-Test Design

Aidah Alkaissi[1,*], Abeer Kabya[1], Shahd Khamayseh[1], Ameen Shakarnah[1], Roa Zeineddin[1], Basel Foqha[1] & Mohammad Dwikat[1]

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Abstract: Hemodialysis patients suffer from pain during arteriovenous fistula punctures. By distracting patients with immersive virtual reality (VR), this discomfort can be lessened. The aim of this study was to evaluate the perception of pain by patients undergoing arteriovenous fistula cannulation during hemodialysis in response to a 360-degree nature film that is viewed through virtual reality headsets. Material and Methods: A pre-test-post-test clinical investigation was conducted with 100 hemodialysis patients. During arteriovenous fistula cannulation, patients were placed in a virtual natural setting using the Oculus Quest 2 headset. To calm patients and visually block them from the cannulation process, the 360-degree VR film included a relaxing natural scene and tranquil background music. Results: There was a statistically significant difference in the mean pain score between the first and second sessions (Mean = 4.79 vs. 2.65, p = 0.000). In the second session (n = 24, 24%), the proportion of patients experiencing moderate pain decreased significantly (p = 0.027) compared with the first session (n = 53, 53%). In both sessions, a somewhat positive association was observed between age and pain (Kendall's tau = 0.221, p = 0.016 in the first session, and 0.273, p = 0.004 in the second). In the initial session, a moderate connection (Eta = 0.317) was observed between occupation and pain. Conclusion: Patients on hemodialysis who used VR reported feeling less pain, which supports the technology's incorporation into routine hemodialysis care procedures. This emphasizes the ability of VR to improve hemodialysis patient care by encouraging a patient-centered approach to pain treatment.

Keywords Hemodialysis, cannulation, pain, arteriovenous fistula, virtual reality, and 360-degree video

Introduction

End-stage renal disease (ESRD), the latter stage of chronic kidney disease (CKD), necessitates hemodialysis due to a marked decline in kidney function. For this treatment, permanent vascular access requires the establishment of an arteriovenous fistula (AVF). The primary cause of discomfort is the pain that is unavoidable when the needle is placed into the fistula. [1]. Three or four times a week, dialysis patients usually have to go through the pain of AVF cannulation. Hassan et al. [2] state that these individuals must endure ongoing discomfort. Also, this treatment is often unpleasant, especially for younger individuals [3].

According to Mirzaei et al. [4], an astonishing 50% of dialysis patients have expressed dissatisfaction with various types of pain, particularly those brought on by AVF cannulation. A study by Asgari et al. [5] reported that 47% of dialysis patients not only fear cannulation pain but also consider it to be the most stressful aspect of their treatment. According to Ibrahim et al. [3] and Aghbolagh et al. [6], up to 80% of patients report feeling moderate to severe pain during AVF cannulation. This underscores the importance of effective pain management strategies to enhance patient care and adherence.

Although managing pain remains a crucial aspect of nursing care, no internationally recognized procedure has been developed to lessen the discomfort associated with cannulation [7]. Local anaesthetics, cryotherapy, EMLA cream, and local thermotherapy have all been studied as potential remedies to reduce cannulation discomfort; however, their analgesic efficacy has not yet been established [4]. Problems with administering local anaesthesia include extended exposure periods, low absorption rates, the possibility of protracted allergic reactions, and skin irritation [8, 9]. Because pharmaceutical therapies have negative effects, are expensive [10], and cause drug tolerance [11], complementary medicine has grown in popularity as a way to alleviate pain [12]. This strategy has become more popular in the nursing care business due to its ease of use, minimal risk of side effects, and affordability compared with traditional methods [13, 14]. Recent research shows that distraction is one of the most effective non-pharmacological analgesic techniques for minimizing discomfort associated with invasive procedures [10, 15].

Previous research on the potential benefits of adopting distraction strategies to lessen pain has proven that these methods can help people focus on less painful stimuli or alter how they perceive their pain. Rischer et al. [16] concluded that games, music, and Virtual Reality (VR) are just a few examples of immersive technologies that fall within the category of these techniques. Furthermore, an Iranian study found that when

[1] Faculty of Nursing, An-Najah National University, Nablus, Palestine
*Corresponding author email: aidah@najah.edu

visual and auditory diversions were employed to treat pain in older individuals, the former was more effective in lessening pain severity than the latter [6]. Similarly, Mokbel et al. [17] conducted a study across hemodialysis facilities and reported substantial reductions in pain intensity following an immersive VR intervention during an AVF puncture.

VR is a potentially effective non-pharmacological treatment because it offers an immersive experience that helps patients feel less anxious and uncomfortable during medical procedures. The technology uses head-mounted displays to generate environments that arouse the senses, providing diversion and psychological escape. This distraction is necessary because research suggests that VR can significantly affect the brain's ability to process pain signals, thereby reducing pain perception [17, 18]. Moreover, Bergomi et al. [19] reported that virtual reality influences attention, emotion, concentration, memory, and other senses, directly or indirectly impacting pain perception and signalling.

Nowadays, technology has a significant impact on day-to-day living. Despite continuous discussion regarding the advantages and disadvantages of this technology, most people agree that it is one of the most significant sources of distraction [10]. VR has been shown to effectively reduce pain in a variety of settings, including pediatric dentistry [20], burn injuries [21], venipuncture in patients with cancer [22], and general adult pain [23]. The effectiveness of virtual reality in relieving pain remains uncertain because some studies have not revealed any discernible differences in this area [24, 25].

The short preview above shows that access to virtual reality for medical purposes has increased. Devices like the Oculus Rift and Samsung Gear VR have created new opportunities to enhance patient treatment outcomes and experiences. There is currently a lack of evidence demonstrating VR's benefits for various patient populations and medical procedures [26, 27]. VR offers a holistic approach to patient care by combining pain management with psychological support, rehabilitation, and patient education. Despite its potential, further scientific research is required to determine whether virtual reality and other diversionary techniques help treat pain. Theories like the gate control mechanisms suggest that distraction alters how pain signals are conveyed to the brain.

Nevertheless, further investigation is required to identify the specific neurological processes implicated [28, 29]. VR allows patients with ESRD to improve their quality of life and adherence to therapy while reducing the discomfort associated with the procedure. The current study examined how patients undergoing arteriovenous fistula cannulation during hemodialysis experience pain in response to a 360-degree virtual reality film they watch through virtual reality headsets. The hypothesis of this study is that compared with receiving conventional care that refers to the regular hemodialysis process that does not involve any pain management measures, the same hemodialysis patients will have less pain during arteriovenous fistula puncture when they participate in the VR intervention, which involves watching a 360-degree virtual reality nature film through a virtual reality headset.

Materials and Methods

Design

A pre-posttest design was employed in a single clinical setting to evaluate the usefulness of virtual reality 360-degree video for pain management.

Participants

The research was conducted from June to December 2023 and included 100 hemodialysis patients from a university hospital in the northern West Bank of Palestine. Participants were chosen using a convenience sample method to ensure consistency with the study's aims. Eligibility criteria mandated that persons be aged between 18 and 80 years, demonstrate orientation to time, location, and person during data collection, and show fundamental literacy skills. Moreover, participants were required to possess unblemished skin at the cannulation site and to be devoid of psychological problems, diabetic neuropathy, and substance abuse. Exclusion criteria encompassed recent analgesic use within 24 hours before the session, unwillingness to participate, or unsuccessful venipuncture on the initial attempt. The sample size was calculated using G*Power 3.1.9.4 to achieve 80% power at a 0.05 alpha level, ensuring statistical power and significance. The study was executed in the hemodialysis unit of the university hospital, where participants received evaluations and interventions following the study's systematic approach.

Study Tools

The research intended to evaluate pain perception during AVF cannulation by integrating traditional treatment methods with a VR distraction strategy executed throughout two sessions. During the initial session, participants had AVF cannulation according to standard clinical protocols without supplementary pain management interventions. Pain levels were assessed pre- and post-procedure using the Numerical Pain Rating Scale (NPRS), with patients well briefed on the technique. The VR distraction approach was integrated during the second session. Prior to the treatment, participants donned a head-mounted display that enveloped them in a tranquil 360-degree natural setting, complemented by relaxing background music. The VR experience commenced 10 minutes prior to the puncture and persisted throughout the process, thereby obstructing the subjects from observing the cannulation. The pain was evaluated pre- and post-procedure utilizing the identical NPRS approach, and the study complied with rigorous infection control methods, including disinfecting the VR headsets with alcohol-based wipes after each use, per manufacturer guidelines.

Participants in the VR intervention were immersed in a virtual world crafted to facilitate relaxation through a serene natural setting and ambient music. The VR headgear diminished pain perception by obstructing their view of the puncture. Immersion in the VR environment was characterized as achieving a profoundly engaged state within the VR when individuals detached from the physical environment and its sensory elements, including visual, auditory, and spatial stimuli. The objective of this immersive encounter was to achieve total sensory dislocation from reality to the artificial domain of the virtual environment, transcending mere distraction to forge a wholly new sensory experience.

This study utilized the Numerical Pain Rating Scale (NPRS) for the subjective evaluation of pain intensity. Derived from McCaffery and Beebe [30], the NPRS is a well-established instrument noted for its ease of use and adaptability in clinical and research settings. The instrument is recognized for its validity and reliability, exhibiting favourable psychometric

characteristics described by Castarleans et al. [31] and Tsze et al. [32]. The NPRS exhibits a reliability coefficient (r = 0.97), hence reinforcing its resilience. The scale is linear from 0 to 10, with 0 denoting no pain and 10 signifying extreme agony. It categorizes pain intensity into four classifications: 0 for no pain, 1-3 for mild pain, 4-6 for moderate pain, and 7-10 for severe pain. Pain levels were assessed before and during the intervention, facilitating a direct comparison between baseline and post-procedure pain levels. The pre-constructed questionnaire utilized for data collection was modified from Mokbel et al. [17], comprising two sections: the first addressing demographic information, including age, gender, marital status, education, employment, income, smoking habits, and dialysis history, and the second assessing pain severity as quantified by the NPRS.

The research adhered to a systematic protocol, with preliminary interviews to elucidate the study's aims and secure informed consent. Participants were informed of their rights during the interviews, including the option to withdraw from the study at any moment. Furthermore, the nursing staff was consulted to guarantee a collaborative atmosphere. The second phase entailed gathering sociodemographic and medical history data, requiring roughly 10 minutes per participant. The third phase entailed executing two sessions: the initial session, designated as the "No Intervention Day," adhered to conventional AVF puncture protocols, whereas the subsequent session, termed the "VR Intervention Day," integrated the VR distraction method. The VR experience, utilizing specialized headgear with goggles and headphones, commenced 10 minutes before the puncture and persisted throughout the process. Pain levels were documented post-puncture in both sessions. In the evaluating phase, pain intensity scores were evaluated pre- and post-procedure, both with and without the VR intervention, utilizing the NPRS [17]. To maintain stringent infection control protocols, the VR headset's components were meticulously cleaned using alcohol-based wipes after each usage, following the manufacturer's recommendations.

Procedural Overview

The process comprises four essential phases: interviews, assessment, implementation, and evaluation. During Phase 1, qualified patients are identified, and informed consent is acquired. Furthermore, nursing personnel are involved to guarantee seamless execution. Phase 2 entails the collection of sociodemographic and medical history information, a procedure that requires roughly 10 minutes to finalize. In Phase 3, the intervention is executed over two sessions. During Session 1 (No Intervention Day), participants have a standard AVF puncture, and their pain severity is documented. During Session 2 (VR Intervention Day), patients don a VR headset while receiving the AVF puncture, and their pain severity is documented. In Phase 4, pain intensity scores from both sessions are compared to evaluate the intervention's efficacy, and the VR components are cleaned and maintained for subsequent usage.

Ethical consideration

The study was approved by the institutional review board (IRB) of An-Najah National University (Ref. Nsg. April 2023/8. The Universal Trial Number (UTN) is U1111-1313-3108. Before the study, all patients were made aware of its goals, protocols, and their right to withdraw from the study at any time and for any reason. Participants provided verbal informed consent after being properly informed about the voluntary nature of their involvement and the strict confidentiality and privacy protections in place. To ensure thorough comprehension and adherence to the study protocol, the nursing staff of the dialysis unit underwent training.

According to the World Medical Association Declaration of Helsinki, this study aimed to evaluate the potential benefits of VR technology for treating pain in patients receiving kidney dialysis in compliance with the guidelines outlined in the research involving human subjects. The participants were fully informed about the technology's benefits, drawbacks, and limitations, and their consent was requested to ensure that they understood both the purpose and their role in the study. Procedures were implemented to protect private information and prevent any unfavorable impacts from VR therapy; a coding system was used to ensure anonymity. The An-Najah National University Hospital research committee formally approved the study's ethical compliance, and the study upheld transparency in all procedures and conclusions.

Statistical analysis

The Statistical Package for Social Sciences Software (SPSS) Version 23 was used for data analysis. The researcher conducted descriptive statistics (Frequencies, Percentages, Means, and Standard Deviations) for all studied variables, indicators, parameters, and measurements related to the study. The following statistical tests were used to analyze the results and test the research hypotheses assuming that the P-Value ≤ 0.05 is considered significant: Paired samples t-test was used to test the differences between the means of the pain scale scores in the first session after canulation and the mean score of the second session after virtual reality. The Chi-Square test (adjusted by Exact Test to account for the low frequency of some categories where the expected count could be less than 5) was used to test the differences in percentages between the levels of pain in the first session after canulation and the second session after VR or relationships between the demographic variables or Fistula and Dialysis variables and pain in 1st session after canulation and 2nd session after virtual reality. Kendall's tau correlations were used to test the relationships between age, pain in the first session after canulation, and pain in the second session after VR, as well as the Eta correlation between occupation and pain in the first session after canulation.

Results and Discussion

Characteristics of Participants

The study sample included 100 participants (36 females and 64 males). The participants were from the age group 61 or above (45%) and the age group 41-60 (43%). Most were married (89%) and had a moderate-income level (93%). Regarding educational level, 50% of the participants had primary school education, 33% had high school education, and approximately 16% had academic education. Regarding the participants' occupations, the sample included 61% housekeepers, 23% workers, only four self-employed persons, and 12% had no occupation. Finally, most of the participants in the study sample were non-smokers

(71%). Table (1) shows the Demographic Data and Characteristics study results.

Table (1): The study Demographic Data and Characteristics (N=100) *

Variable	Category	N	%
Age	40	12	12.0%
	(41-60)	43	43.0%
	61 or above	45	45.0%
	Total	100	100.0%
Gender	Male	64	64.0%
	female	36	36.0%
	Total	100	100.0%
Marital status	Single	9	9.0%
	Married	89	89.0%
	Widow	1	1.0%
	Divorce	1	1.0%
	Total	100	100.0%
Income level	Low	5	5.0%
	Moderate	93	93.0%
	High	2	2.0%
	Total	100	100.0%
Educational level	primary school	50	50.5%
	High school	33	33.3%
	Academic	16	16.2%
	Total	99	100.0%
Occupation	self-employed	4	4.0%
	worker	23	23.0%
	housekeeper	61	61.0%
	None	12	12.0%
	Total	100	100.0%
Smoking	Yes	29	29.0%
	No	71	71.0%
	Total	100	100.0%

Comparisons between the pain scales in the first session after canulation and the second session after virtual reality

The following Table (2) shows the results of the statistical testing and comparisons between the pain scales in the first session after canulation and the second session after VR

Table (2): Comparisons between the pain scale scores in the first session after canulation and the second session after virtual reality (N=100). **

Pain during the first session	Pain in the second session	Mean difference	P-value
4.79 ± 1.67	2.65 ± 1.56	2.14 ± 1.68	0.000*

* Mean difference is significant at the 0.05 level. **P-value resulted from the Paired sample t-test for the quantitative variables; the numbers in the Table represent (Mean ± Standard deviation).

The results in Table (2) above show a significant difference at the 0.05 level between the pain scale in the first session after canulation and the pain scale in the second session after VR. The mean of the pain scale in the second session (Mean=2.65) is significantly lower than in the first session (Mean=4.79). The p-value of the test was 0.000.

Comparisons between the percentages of pain levels in the first session after canulation and the second session after virtual reality

Table (3) shows the results of the statistical testing and comparisons between the percentages of pain levels in the first session after canulation and the second session after virtual reality:

Table (3): Comparisons between the percentages of pain levels in the first session after canulation and the second session after virtual reality (N=100). **

Session Pain Level	Pain Before (session1)	Pain After (session2)	P-value
Mild pain	27 (27%)	74 (74%)	0.000*
Moderate pain	53 (53%)	24 (24%)	0.000*
Severe pain	20 (20%)	2 (2%)	0.000*
Total	100 (100%)	100 (100%)	----

*Positive difference is significant at the 0.05 level. **P-value resulted from the Z-test of differences between the percentages for categorical variables; the numbers in the Table represent frequencies and percentages N (%).

Table (3) shows a significant difference at the 0.05 level between the percentages of pain levels in the first session after canulation and the pain levels in the second session after virtual reality. The total percentage of mild pain in the first session (n=27, p=27%) was significantly lower than in the second session (n=74, p=74%); p= 0.000. On the other hand, the total percentage of severe pain in the first session (n=20, p=20%) is significantly higher than the total percentage of severe pain in the second session (n=2, p=2%), the p= 0.000, and the total percentage of moderate pain in the first session (n=53, p=53%) is significantly higher than the total percentage of moderate pain in the second session (n=24, p=24%), p= 0.000.

The relationships between demographic variables and pain in 1st session after canulation and 2nd session after virtual reality

Table (4) shows the results of the statistical testing of the relationships between demographic variables and pain in 1st session after canulation and 2nd session after virtual reality.

Table (4): Relationships between demographic variables and pain in 1st session after canulation and 2nd session after virtual reality (N=100). **

Variable	Category	Pain Before (session1)				Pain After (session2)			
		Mild pain	Moderate pain	Severe pain	P-value	Mild pain	Moderate pain	Severe pain	P-value
Age	40	4(33.3%)	7(58.3%)	1(8.4%)	0.031*	9(75%)	3(25%)	0(0%)	0.024*
	41-60	14(32.6%)	24(55.8%)	5(11.6%)		39(90.7%)	3(7%)	1(2.3%)	
	61 or above	9(20%)	22(48.9%)	14(31.1%)		26(57.8%)	18(40%)	1(2.2%)	
Gender	Male	17(26.6%)	36(56.3%)	11(17.2%)	0.586	50(78.1%)	14(21.9%)	0(0%)	0.117
	female	10(27.8%)	17(47.2%)	9(25%)		24(66.7%)	10(27.8%)	2(5.6%)	
Marital status	Single	2(22.2%)	7(77.8%)	0(0%)	0.201	7(77.8%)	2(22.2%)	0(0%)	1.000
	Married	25(28.1%)	45(50.6%)	19(21.3%)		65(73%)	22(24.7%)	2(2.2%)	
	Widow	0(0%)	0(0%)	1(100%)		1(100%)	0(0%)	0(0%)	
	Divorce	0(0%)	1(100%)	0(0%)		1(100%)	0(0%)	0(0%)	
Income level	Low	1(20%)	3(60%)	1(20%)	0.914	5(100%)	0(0%)	0(0%)	0.454
	Moderate	26(28%)	49(52.7%)	18(19.4%)		68(73.1%)	23(24.7%)	2(2.2%)	
	High	0(0%)	1(50%)	1(50%)		1(50%)	1(50%)	0(0%)	
Educational level	primary school	17(34%)	26(52%)	7(14%)	0.240	39(78%)	10(20%)	1(2%)	0.397
	High school	5(15.2%)	20(60.6%)	8(24.2%)		22(66.7%)	11(33.3%)	0(0%)	
	Academic	4(25%)	7(43.8%)	5(31.3%)		12(75%)	3(18.8%)	1(6.3%)	
Occupation	self-employed	3(75%)	1(25%)	0(0%)	0.035*	4(100%)	0(0%)	0(0%)	0.300
	worker	3(13%)	13(56.5%)	7(30.4%)		19(82.6%)	4(17.4%)	0(0%)	
	housekeeper	16(26.2%)	32(52.5%)	13(21.3%)		40(65.6%)	19(31.1%)	2(3.3%)	
	None	5(41.7%)	7(58.3%)	0(0%)		11(91.7%)	1(8.3%)	0(0%)	
Smoking	Yes	10(34.5%)	15(51.7%)	4(13.8%)	0.439	22(75.9%)	7(24.1%)	0(0%)	0.767
	No	17(23.9%)	38(53.5%)	16(22.5%)		52(73.2%)	17(23.9%)	2(2.8%)	

* The relationships are significant at the 0.05 level. **The P-values in the Table result from the Chi-square tests of the relationship between the categorical variables; the numbers in the Table represent frequencies and percentages N (%). The chi-square tests were adjusted using the Exact Test to account for the low frequency of some categories where the expected count could be less than 5.

The results in Table (4) show a significant relationship at the 0.05 level between the age and the pain in the first session. The p-value of the test is 0.031. The percentages of severe pain increase as the age increases, where the percentage for the age group (lower than or equal to 40) is (n=1, p=8.4%) and the percentage for the age group (41-60) which is (n=5, p=11.6%) are significantly lower than the percentage of severe pain for the age group (61 or above) which is (n=14, p=31.1%). The results also show that the percentages of mild pain decrease as the age increases, where the percentage for the age group (lower than or equal to 40) is (n=4, p=33.3%), and the percentage for the age group (41-60) which is (n=14, p=32.6%), are significantly higher than the percentage of mild pain for the age group (61 or above),

which is (n=9, p=20%). This means that the relationship between age and pain in the first session is linear and can be tested using Kendall's tau correlation coefficient, which is appropriate for ordinal variables. The results of Kendall's tau in Table (5) below show a significant positive correlation between age and pain in the first session. The value of the correlation coefficient was moderate (Kendall's tau=0.221), and the p-value was 0.012.

The results in Table (4) above also show a significant relationship at the 0.05 level between the age and the pain in the second session, and the p-value of the test is 0.024. The percentages of severe pain are increasing slightly as the age increases, where the percentage for the age group (lower than or equal to 40) which is (n=0, p=0%) is lower than and the percentages for the age group (41-60) which is (n=1, p=2.3%) and the percentage of severe pain for the age group (61 or above) which is (n=1, p=2.2%). The results also show that the percentage for the age group (lower than or equal to 40), which is (n=9, p=75%), is significantly higher than the percentage of mild pain for the age group (61 or above), which is (n=26, p=57.8%). This also means that the relationship between age and pain in the second session could be linear and tested using Kendall's tau correlation coefficients. The results of Kendall's tau in Table (5) below show a significant positive correlation between age and pain in the second session. The value of the correlation coefficient was moderate (Kendall's tau=0.262), and the p-value was 0.002.

The results in Table (4) above show that there is a significant relationship at the 0.05 level between the occupation and the pain in the first session, the percentages of severe pain for workers (n=7, p=30.4%) and for housekeepers (n=13, p=21.3%) are significantly higher than the percentages of severe pain for the other occupation groups. The percentage of mild pain for the self-employed participants (n=3, p=75%) is significantly higher than that for the other occupation groups. The p-value of the test is 0.035. The relationship between occupation and pain in the first session can also be evaluated by the (Nominal by Interval) Eta correlation coefficient, which is appropriate for the nominal with ordinal variables. The results of Eta in Table (6) below show a moderate correlation between occupation and pain in the first session; the correlation coefficient value is moderate (Eta=0.317).

Table (5): Kendall's tau correlations between age, pain in the first session after canulation, and pain in the second session after virtual reality (N=100).

		Age	Pain Before (session1)	Pain After (session2)
Age	Correlation Coefficient	1.000	0.221*	0.262**
	Sig. (2-tailed)		0.012	0.002
Pain Before (session1)	Correlation Coefficient	0.221*	1.000	0.387**
	Sig. (2-tailed)	0.012		0.000
Pain After (session2)	Correlation Coefficient	0.262**	0.387**	1.000
	Sig. (2-tailed)	0.002	0.000	

*. The correlation was significant at the 0.05 level (2-tailed).

**. The correlation is significant at the 0.01 level (2-tailed).

Table (6): Eta correlation between the occupation and pain in the first session after canulation (N=100).

		Value
Nominal by Interval	Occupation Dependent	0.116
Eta	Pain Before (session1) Dependent	0.317

Relationships between Fistula and Dialysis variables and pain in 1st session after canulation and 2nd session after virtual reality

The following Table (7) shows the results of the statistical testing of relationships between Fistula and Dialysis variables and pain in 1st session after canulation and 2nd session after virtual reality:

*P-values in the Table resulting from the Chi-square tests of the relationship between the categorical variables; the numbers in the Table represent frequencies and percentages N (%). The chi-square tests were adjusted using the Exact Test to account for the low frequency of some categories where the expected count could be less than 5.

The results in Table (7) above show that there are no significant relationships at the 0.05 level between the Fistula and Dialysis variables and pain in 1st session after canulation and 2nd session after virtual reality; the p-values of the tests are higher than 0.05 corresponding to all fistula and dialysis variables.The following Table (8) shows the results of the statistical testing of the relationship between the etiology of nephropathy and pain in 1st session after canulation and 2nd session after virtual reality.

Table (7): Relationships between Fistula and Dialysis variables and pain in 1st session after canulation and 2nd session after virtual reality (N=100). *

Variable	Category	Pain Before (session1)				Pain After (session2)			
		Mild pain	Moderate pain	Severe pain	P-value	Mild pain	Moderate pain	Severe pain	P-value
Fistula age	1 year	9(29%)	17(54.8%)	5(16.1%)	0.617	23(74.2%)	8(25.8%)	0(0%)	0.896
	(1-3)	11(23.9%)	22(47.8%)	13(28.3%)		35(76.1%)	10(21.7%)	1(2.2%)	
	(3-5)	5(29.4%)	11(64.7%)	1(5.9%)		12(70.6%)	4(23.5%)	1(5.9%)	
	more than 5 years	2(33.3%)	3(50%)	1(16.7%)		4(66.7%)	2(33.3%)	0(0%)	
Fistula site	Right hand	6(30%)	8(40%)	6(30%)	0.345	14(70%)	6(30%)	0(0%)	0.722
	Left hand	21(26.3%)	45(56.3%)	14(17.5%)		60(75%)	18(22.5%)	2(2.5%)	
Fistula type	Brachiocephalic	19(24.1%)	44(55.7%)	16(20.3%)	0.419	60(75.9%)	17(21.5%)	2(2.5%)	0.414
	Radio cephalic	8(38.1%)	9(42.9%)	4(19%)		14(66.7%)	7(33.3%)	0(0%)	
Duration of hemodialysis	1 year	2(13.3%)	9(60%)	4(26.7%)	0.811	11(73.3%)	4(26.7%)	0(0%)	0.731
	(1-3) year	15(33.3%)	22(48.9%)	8(17.8%)		36(80%)	8(17.8%)	1(2.2%)	
	(3 -5)	4(20%)	12(60%)	4(20%)		13(65%)	7(35%)	0(0%)	
	more than 5 years	6(30%)	10(50%)	4(20%)		14(70%)	5(25%)	1(5%)	
Number of dialysis sessions per week	one session	0(0%)	0(0%)	0(0%)	0.851	0(0%)	0(0%)	0(0%)	1.000
	two sessions	2(40%)	2(40%)	1(20%)		4(80%)	1(20%)	0(0%)	
	three sessions	25(27.2%)	49(53.3%)	18(19.6%)		68(73.9%)	22(23.9%)	2(2.2%)	
	more than 3 sessions	0(0%)	2(66.7%)	1(33.3%)		2(66.7%)	1(33.3%)	0(0%)	
Duration of dialysis session	3 h	0(0%)	0(0%)	0(0%)	0.365	0(0%)	0(0%)	0(0%)	0.282
	(3 hrs.)	10(43.5%)	10(43.5%)	3(13%)		19(82.6%)	3(13%)	1(4.3%)	
	(3 hrs. and 30 minute)	6(25%)	13(54.2%)	5(20.8%)		15(62.5%)	9(37.5%)	0(0%)	
	(4 h)	11(20.8%)	30(56.6%)	12(22.6%)		40(75.5%)	12(22.6%)	1(1.9%)	

Table (8): Relationships between etiology of nephropathy and pain in 1st session after canulation and 2nd session after virtual reality (N=100) *

Variable	Category	Pain Before (session1)				Pain After (session2)			
		Mild pain	Moderate pain	Severe pain	P-value	Mild pain	Moderate pain	Severe pain	P-value
The etiology of nephropathy	idiopathic	0(0%)	5(83.3%)	1(16.7%)	0.239	4(66.7%)	2(33.3%)	0(0%)	0.428
	Diabetic	6(60%)	4(40%)	0(0%)		10(100%)	0(0%)	0(0%)	
	hypertension	5(45.5%)	5(45.5%)	1(9.1%)		8(72.7%)	3(27.3%)	0(0%)	
	glomerulonephritis	1(25%)	1(25%)	2(50%)		2(50%)	2(50%)	0(0%)	

	lupus	0(0%)	2(100%)	0(0%)		0(0%)	2(100%)	0(0%)	
	polycystic kidney	0(0%)	2(100%)	0(0%)		1(50%)	1(50%)	0(0%)	
	obstructive or urological problems	0(0%)	1(50%)	1(50%)		2(100%)	0(0%)	0(0%)	
	other	6(40%)	8(53.3%)	1(6.7%)		11(73.3%)	4(26.7%)	0(0%)	
	Diabetes, Hypertension	9(23.7%)	17(44.7%)	12(31.6%)		30(78.9%)	6(15.8%)	2(5.3%)	
	hypertension, polycystic kidney	0(0%)	1(100%)	0(0%)		1(100%)	0(0%)	0(0%)	
	hypertension, other	0(0%)	3(75%)	1(25%)		2(50%)	2(50%)	0(0%)	
	diabetic, other	0(0%)	0(0%)	1(100%)		0(0%)	1(100%)	0(0%)	
	diabetic, hypertension, other	0(0%)	1(100%)	0(0%)		0(0%)	1(100%)	0(0%)	
	hypertension, lupus	0(0%)	1(100%)	0(0%)		1(100%)	0(0%)	0(0%)	
	diabetes, lupus	0(0%)	1(100%)	0(0%)		1(100%)	0(0%)	0(0%)	
	diabetic, glomerulonephritis	0(0%)	1(100%)	0(0%)		1(100%)	0(0%)	0(0%)	

*P-values in the Table resulting from the Chi-square tests of the relationship between the categorical variables; the numbers in the Table represent frequencies and percentages N (%). The chi-square tests were adjusted using the Exact Test to account for the low frequency of some categories where the expected count could be less than 5.

The results in Table (8) show no significant relationship at 0.05 level between the Etiology of nephropathy and pain in 1st session after canulation and 2nd session after virtual reality; the p-values of the tests are higher than 0.05.

Discussion

This study aimed to evaluate how well a 360° virtual reality film can reduce the discomfort experienced by hemodialysis patients during fistula cannulation. The outcomes demonstrated that the pain immediately following cannulation in the second session was considerably lessened when virtual reality was used. The study also demonstrated the influence of age and occupational achievement on pain perception and a strong correlation between the pain experienced during the initial cannulation session and patient characteristics. However, additional analytical analysis showed that no statistically significant relationship was found between the pain experienced immediately following the first session's cannulation and any other variables, including gender, marital status, the number of hemodialysis sessions per week, the duration of these sessions, the fistula's longevity, and smoking status. These findings suggest that these variables may not be necessary to modify the number of pain hemodialysis patients experience during fistula cannulation, at least in the initial evaluation. By deliberately diverting a patient's attention, distraction therapies aim to lower pain perception and raise pain thresholds [10]. Because relaxation programs release endorphins into the brain, which lessen pain, these techniques help patients feel blissful and relax their muscles [33].

Compared with standard therapy, the results demonstrated a statistically significant ($p<0.001$) decrease in subjective pain intensity during virtual reality intervention sessions. According to Hua et al. [34], VR apps can reduce burn victims' time in therapy while also helping them feel less scared and uncomfortable. Brown et al. suggested that the use of pharmaceutical therapy in conjunction with distraction tactics may help burn wound patients feel less nervous and uncomfortable. This treatment could ultimately result in enhanced healing and regeneration of the epithelium [35]. VR applications dramatically decreased discomfort, according to research on chronic pain syndromes [36]. VR has been shown by Ashjian et al. to significantly reduce pain in hospitalized patients, suggesting that it could be a useful adjunctive pain management tool [23].

In addition, studies have investigated how vertical reality affects musculoskeletal pain reduction [37] and stroke rehabilitation [38]. According to Piskorz et al., virtual reality therapy reduced pain intensity by 22.48% and 30.57% over two sessions [39]. Schmitt et al. reported that children with burn injuries experienced reductions in both sensory and emotional pain components of up to 27% and 32%, respectively, following virtual reality therapies [40]. VR reality was found to reduce venipuncture discomfort in pediatric cancer patients by 12.7%, according to an evaluation conducted by Gershon et al. [41]. The outcomes of this investigation align with numerous other research findings that illustrate the noteworthy influence of VR interventions on mitigating pain ratings in children undergoing various medical procedures, including blood collection [42], venous port access in pediatric oncology units [43], and the utilization of Huber needles for port access in pediatric haematology-oncology cohorts [44]. On the other hand, VR therapies had a small effect size. They found that while VR did not considerably lessen the degree of discomfort or fear that children in need of vascular access experienced during needle procedures, it did increase participant satisfaction [17].

In the meantime, Brown et al. [35] highlighted the benefits of a multimodal approach to patient care by suggesting that the use of pharmaceuticals and diversionary tactics not only lessens discomfort and anxiety when treating burn wounds but also encourages the regeneration and repair of epithelial tissue. During haemodialysis patients' AVF punctures, the results of this study further confirm the increasing amount of data that VR distraction strategies can reduce discomfort and improve patient satisfaction. Our findings support the Elzeky et al. study by showing that VR distraction dramatically lowers pain and anxiety while raising patient satisfaction levels. According to Elzeky et al., VR distraction is a safe, affordable, and non-pharmacological option for haemodialysis patients having AVF punctures. These results agree with our study's findings and demonstrate VR's promise as a cutting-edge pain treatment technique in dialysis environments [45].

The findings of Namazinia et al., who looked into how VR distraction tactics affected hemodialysis patients' perceptions of discomfort during AVF needle insertion, also align with the findings of our study. In comparison to the control group (7.6 ± 0.8, $p < 0.002$), their study found that patients who used VR experienced a statistically significant decrease in pain scores (mean pain score: 5.1 ± 0.9). Furthermore, compared to patients in the control group, most patients in the intervention group felt moderate pain. These results prove that using VR distraction as a standard non-pharmacological treatment in hemodialysis facilities can improve clinical results and patient comfort [46].

The results of Sen and Bakar's study, which examined how VR distraction-affected 60 hemodialysis patients' discomfort and satisfaction in a Turkish public hospital, also complement our findings. Their study showed that patients who used VR for five minutes in total—three minutes during AVF cannulation and two minutes prior saw a significant decrease in pain and increased satisfaction. The viability and usefulness of VR as a non-invasive, readily implementable intervention that improves patients' hemodialysis experiences are further supported [47].

Furthermore, our work supports the findings of Şimşek and Aksoy's investigation on the effect of VR distraction on pain perception during fistula cannulation. Their research showed that patients in the intervention group who watched VR movies for about five minutes during the cannulation of AVF had significantly lower mean pain scores. The lasting analgesic impact of VR was further supported by within-group comparisons that revealed a persistent decrease in pain levels in follow-up evaluations. These findings prove that VR technology can be incorporated into routine clinical practice as a convenient and successful non-pharmacological pain treatment strategy for hemodialysis patients [48].

When taken as a whole, the findings of our study's consistency with other research shows how VR is increasingly being acknowledged as a useful tool for hemodialysis patients' comfort and pain management. The research supports using VR distraction techniques in dialysis settings to reduce procedure discomfort, increase patient satisfaction, and improve overall treatment experiences. Future studies should examine the long-term advantages of virtual reality therapies and their possible uses in other invasive nephrology procedures and fields. By integrating VR into routine patient care, hemodialysis centers may provide a more patient-centered approach that puts their patients' comfort, engagement, and well-being first.

There is a clear need for more studies to find effective ways to lessen the pain and suffering associated with invasive and needle-based procedures. Larger participant cohort studies are also necessary to validate and support the results of this investigation, ensuring that the conclusions drawn are solid and applicable to various clinical contexts and demographics. The increased focus on research is essential for improving patient care and progressing pain treatment, especially when invasive procedures are inevitable.

Conclusion

This study supports incorporating VR distraction techniques in hemodialysis, especially during AVF cannulation, as an effective means to improve patient outcomes. VR has substantially reduced pain and enhanced patient satisfaction, rendering it a complement to conventional care. Research indicates a significant correlation between age and pain intensity, with older patients reporting greater pain levels, whilst younger persons have less severe suffering. Moreover, occupation significantly influences pain perception, with employees and housekeepers experiencing more intense pain than self-employed persons. By supplementing pain management, VR can help hemodialysis practitioners prioritize patient comfort, engagement, and well-being. The need for non-pharmacological pain management innovation and VR's transformative potential in patient care are highlighted in this study.

Implications

The findings of this study, together with a substantial amount of recent research, lend support to the use of VR as a safe, noninvasive supplement to lessen the discomfort associated with AVF cannulation and enhance patient comfort during hemodialysis sessions. Therefore, Palestinian nurses employed by hemodialysis centers should undergo comprehensive on-the-job training. These training programs aim to improve patients' emotions of security and well-being during AVF cannulation procedures by arming nurses with the knowledge and skills they need to integrate VR-based diversionary tactics into standard nursing procedures.

Limitations

The study's conclusions are based on a sample obtained from a single hospital, perhaps restricting the generalizability of the findings to other healthcare environments. The sample population in this study may not sufficiently represent the wider, more diverse patient groups found across various geographies or healthcare systems. Diverse patient demographics, socioeconomic variables, disease incidence, healthcare legislation, and clinical practices can all affect outcomes; therefore, the findings cannot be extrapolated to other populations or regions. Moreover, the particular context of the hospital, including available resources, treatment protocols, and staff expertise, may not accurately represent practices in other environments, potentially impacting outcomes dramatically. The study's dependence on data from a singular institution may impose constraints on its external validity. The incorporation of more different settings or other hospitals would have enhanced the external generalizability of the findings.

Availability of data and materials

The corresponding author will furnish the data substantiating the study's conclusions upon a reasonable request.

Author's contribution

The authors confirm contribution to the paper as follows: AA: conceptualization, study design, data gathering, analysis, interpretation, composing, amending, and rigorously evaluating the essay. AK: conceptualization, study design, data gathering, analysis, interpretation. SK: conceptualization, study design, data gathering, analysis, interpretation. AS: conceptualization, study design, data gathering, analysis, interpretation. RZ: conceptualization, study design, data gathering, analysis, interpretation. BF: conceptualization, study design, data gathering, analysis, interpretation. MD: analysis, interpretation, rigorously evaluating the essay. All authors significantly contributed to this research. Moreover, all authors granted final clearance for the manuscript's publication, chose the journal for submission, and pledged accountability for all facets of this research.

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Conflict of interest

The Author(s) declare(s) that there is no conflict of interest. This manuscript is a students' project.

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