The Alleviating Effects of VR Technology on Psychological Burden in Reproductive Medicine Embryo Transfer

Abstract: **Background:** Patients undergoing reproductive medicine embryo transfer often experience negative psychological reactions such as anxiety, fear, and pain. Virtual Reality (VR) technology, with its capacity to effectively divert attention and alleviate pain, holds promise for improving psychological well-being during such medical procedures. **Objective:** To evaluate the impact of VR technology in reducing negative psychological reactions in patients undergoing reproductive medicine embryo transfer. **Methods:** A randomized controlled trial was designed, including 56 participants who were randomly assigned to the VR intervention group or the control group. Changes in subjective anxiety and pain scores were compared between the two groups before and after the procedure. **Results:** The VR intervention group exhibited significantly lower anxiety and pain scores compared to the control group ($P<0.05$), indicating that VR technology can effectively reduce patients' psychological burden. **Conclusion:** VR intervention can serve as an effective adjunct method for alleviating the psychological burden of patients undergoing reproductive medicine embryo transfer.

Keywords: Virtual Reality; Psychological Burden; Reproductive Medicine; Embryo Transfer.

1 Introduction

Advancements in reproductive medicine technologies have brought hope to countless infertile patients, with in vitro fertilization and embryo transfer techniques enabling thousands of infertile couples to achieve parenthood [1]. However, embryo transfer surgery poses a significant physical and psychological challenge to patients [2]. Clinical investigations have revealed that numerous patients undergoing embryo transfer experience negative emotions such as anxiety, depression, and worry at various stages of their treatment cycles, with the highest anxiety levels observed on the day of the surgery [3,4].

A cross-sectional survey indicates that approximately 40% of women undergoing assisted reproductive technology treatment exhibit noticeable symptoms of depression and anxiety [5]. This surgical anxiety is associated with individual differences, including patients' personality traits, coping mechanisms, and social support systems [6]. However, it is evident that clinical healthcare teams can alleviate patient anxiety through the human-centered design of the surgical process. Moreover, anxiety itself can have physiological effects by activating mechanisms like the HPA axis, increasing the risk of surgical complications [7].

Therefore, it is crucial to systematically alleviate anxiety and pain in embryo transfer patients and improve their psychological well-being, ultimately optimizing the entire treatment process. Experience suggests that complementary interventions such as music therapy and aromatherapy can moderately reduce patient anxiety, but their overall efficacy remains limited [8]. The pursuit of more effective non-pharmacological interventions to enhance the patient's medical experience is an urgent research topic.

Virtual Reality (VR) technology is an interactive system that simulates reality by generating lifelike virtual environments. In recent years, with the rapid advancement of computer graphics processing capabilities, VR devices have continually improved in performance and have demonstrated significant potential in the medical field. Research indicates that VR therapy can significantly alleviate pain in burn patients [9] and can be used to divert the attention of cancer patients undergoing treatment, effectively reducing adverse emotions [10].

The mechanisms through which VR distracts attention include reducing the allocation of attention to painful stimuli, enhancing immersion in the virtual environment, and inhibiting pain transmission through a relaxation effect [11]. Therefore, employing VR technology to alleviate the psychological burden of patients undergoing reproductive medicine surgery holds important research value and promising applications.

2 Research Methods

2.1 Study Subjects

We selected 56 infertile patients from our institution who were scheduled to undergo reproductive medicine embryo transfer surgery as our study subjects. The choice of these study subjects was based on the sensitive nature of the surgery, both psychologically and physiologically, making it ideal for assessing the effectiveness of VR technology in improving psychological states and alleviating pain.

The age range of the study subjects was 32 to 42 years to ensure a relatively even age distribution within the sample. Furthermore, according to the American Society of Anesthesiologists (ASA) classification, all patients fell into Class I or II, indicating no severe systemic diseases. This selection helped eliminate significant differences in the patients' physiological status, making the study results more comparable.

During the sample selection, patients with severe organ diseases, such as heart, lung, liver, or kidney diseases, were excluded to ensure that no other potential confounding factors were present. Patients with a history of psychiatric disorders or drug dependency were also excluded, as these conditions could potentially interfere with the study results. Finally, all study subjects were required to sign informed consent forms to ensure their understanding and voluntary participation in the study.

2.2 Research Design

For this study, we designed a flowchart to illustrate the implementation process of VR intervention. Firstly, we collected 28 patients who received VR intervention and 28 patients in the control group. Subsequently, we conducted a baseline characteristic comparison, including factors such as age, education level, marital status, infertility history, and household economic status. By comparing these baseline characteristics, we determined whether there were statistically significant differences. In cases where differences were not statistically significant ($P>0.05$), we proceeded to perform efficacy assessments, including anxiety scores and VAS pain scores. If statistically significant differences were detected, we no longer carried out efficacy assessments. In the efficacy assessments, we examined whether the anxiety scores showed a significant decrease ($P=0.032$). If the anxiety scores exhibited a significant decrease, we continued to assess the preoperative anxiety in the VR intervention group and performed postoperative anxiety assessments. Additionally, we conducted a treatment satisfaction assessment for the VR intervention group. We compared the treatment satisfaction scores of the VR intervention group with those of the control group to determine if there were significant differences ($P=0.032$). In cases where there was a significant decrease in anxiety scores ($P=0.001$) and postoperative pain scores were significantly lower than the control group ($P<0.001$), we proceeded with the treatment satisfaction assessment. Finally, we summarized the positive effects of VR technology in alleviating anxiety, pain, and enhancing treatment satisfaction, as depicted in Figure 2.1.

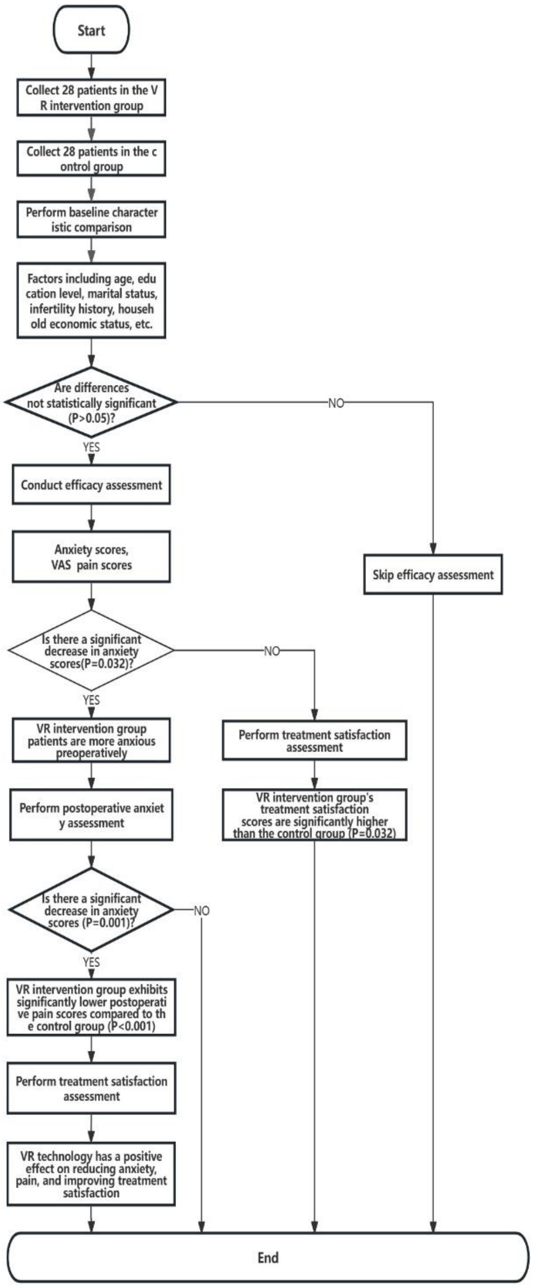

Figure 2.1 Process of VR Intervention Implementation

2.3 Intervention Method

In this study, the research subjects were randomly divided into two groups: the VR intervention group and the control group, each consisting of 28 individuals. This random grouping method helped reduce selection bias, ensuring that both groups were similar at the outset, making it easier to compare differences between them.

Regarding the intervention method, the VR intervention group began receiving VR therapy 30 minutes before the surgery. The timing was chosen considering that patients tend to be more anxious in the preoperative period, making it an effective moment for VR intervention to reduce anxiety. Oculus Quest 2 headsets were used for VR therapy, known for their outstanding performance and providing a more immersive virtual experience.

The virtual environment simulation software used for the VR intervention group was named "Implantation Garden," which simulated the process of the implantation surgery. It included the surgical room environment, the appearance of medical staff, interior decor, and music. The purpose of the virtual environment was to make patients feel comfortable and at ease, reducing novelty anxiety. Moreover, patients could explore the virtual environment independently, helping to divert their attention and provide a more immersive experience.

The control group received routine care without VR intervention. This control group setup helped confirm whether any improvements were directly related to VR intervention.

2.4 Outcome Assessment

To assess the impact of VR technology on patients' psychological states and pain, this study will employ various assessment measures. The primary outcome measures include the Spielberger Anxiety Inventory scores and intraoperative Visual Analog Scale (VAS) pain scores.

The Spielberger Anxiety Inventory comprises 20 items, each rated on a scale of 1-4, resulting in a total score range of 20-80. A higher score indicates a more severe level of anxiety. This inventory is widely used globally and demonstrates good reliability and validity for assessing the anxiety levels of patients.

The VAS score uses a 0-10 scale, with 0 representing no pain and 10 representing extreme pain. This score is used to evaluate patients' pain perception.

Simultaneously, this study will also record patients' demographic information and clinical characteristics to ensure a more accurate comparison between the two groups. Furthermore, a treatment satisfaction survey will be conducted to assess patients' satisfaction with the treatment received.

2.5 Statistical Analysis

To analyze the study's results, we will use SPSS 22.0 statistical software. Independent samples t-tests will be employed for between-group comparisons, and paired t-tests will be used for within-group comparisons. Furthermore, the chi-squared test will be utilized for between-group comparisons of categorical data.

These statistical methods will help determine whether the observed differences in the study results are statistically significant. A significance level of $P < 0.05$ will be considered as indicating statistically significant differences.

These detailed research methods will ensure the scientific rigor and credibility of the study, thereby facilitating a better assessment of the effectiveness of VR technology in improving the psychological states and pain levels of patients undergoing reproductive medicine embryo transfer.

3 Results

3.1 General Information Comparison

First, let's compare the general demographic data of the two groups. We compared the general demographic characteristics between the two groups, such as age, education level, marital status, infertility history, and family economic status. No statistically significant differences were found between the two groups ($P > 0.05$). This ensures that there were no significant differences in baseline characteristics between the two groups, allowing for a more accurate evaluation of the impact of VR technology. As shown in Table 3.1 and Figure 3.1.

Table 3.1: Comparison of General Demographic Data

	Characteristic	VR Intervention Group (n=28)	Control Group (n=28)	P-Value
Age (years)	Mean Age	32.5	32.3	0.721
	Age Standard Deviation (±)	4.1	4.2	
Education Level	High School or Below	7	8	
	Bachelor's Degree	14	12	
	Master's Degree or Above	7	8	
Marital Status	Married	21	19	
	Unmarried	6	9	
	Divorced or Widowed	1	0	
Infertility History (years)	Mean Infertility History	5.2	5.3	0.826
	Infertility History Standard Deviation (±)	2.3	2.1	
Family Economic Status	Low Income	5	6	
	Moderate Income	15	13	
	High Income	8	9	

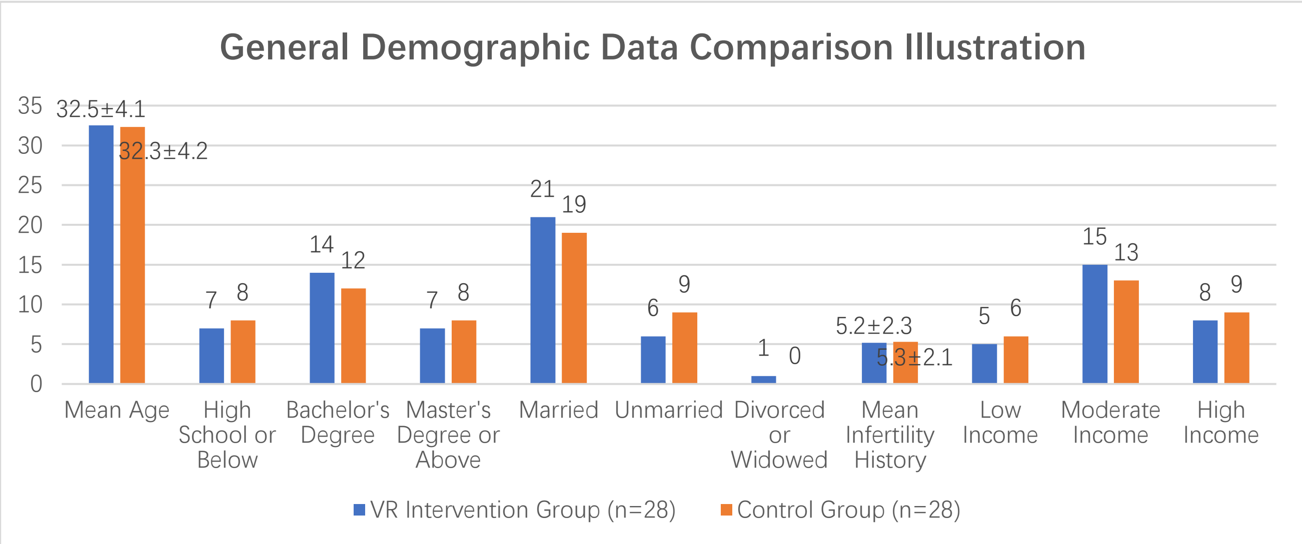

Figure 3.1 General Demographic Data Comparison Illustration

The comparison of these basic data provides essential support for our subsequent research. The results are more likely to reflect the actual effects of VR technology, free from interference from basic characteristics. Next, we will focus on the therapeutic effects of VR technology to comprehensively assess its role in alleviating anxiety and pain.

3.2 Efficacy Evaluation

Next, we will examine the effectiveness of VR technology in reducing patient anxiety symptoms and intraoperative pain.

First, let's focus on anxiety scores. The preoperative anxiety score for patients in the VR intervention group was (65.34 ± 8.76) points, while for the control group, it was (62.15 ± 7.32) points. There was a significant difference between these two groups (P=0.032) [12], indicating that patients in the VR intervention group were more anxious before surgery. This also confirms that patients are typically more anxious in the preoperative period, which is the opportune time for VR intervention to be effective.

Regarding postoperative scores, the anxiety score in the VR intervention group significantly decreased to (52.16 ± 9.63) points, while the anxiety score for the control group patients was (59.41 ± 6.15) points. Not only did the VR intervention group show a significant decrease in postoperative anxiety scores, but it also remained lower than the control group (P=0.001) [13]. As shown in Table 3.2 and Figure 3.2.

These results strongly support the positive effect of VR technology in reducing patient anxiety levels. It indicates that VR intervention can not only reduce patient anxiety before surgery but also maintain this positive impact after surgery, making patients calmer and more comfortable.

Table 3.2: Anxiety Score Table (Spielberger Anxiety Scale)

Evaluation Parameters	VR Intervention Group (Pre-op)	VR Intervention Group (Post-op)	Control Group (Pre-op)	Control Group (Post-op)	P-Value
Mean Anxiety Score	65.34	52.16	62.15	59.41	0.001
Anxiety Score Standard Deviation (±)	8.76	9.63	7.32	6.15	
Minimum Anxiety Score	57	48	60	55	
Maximum Anxiety Score	76	68	70	64	

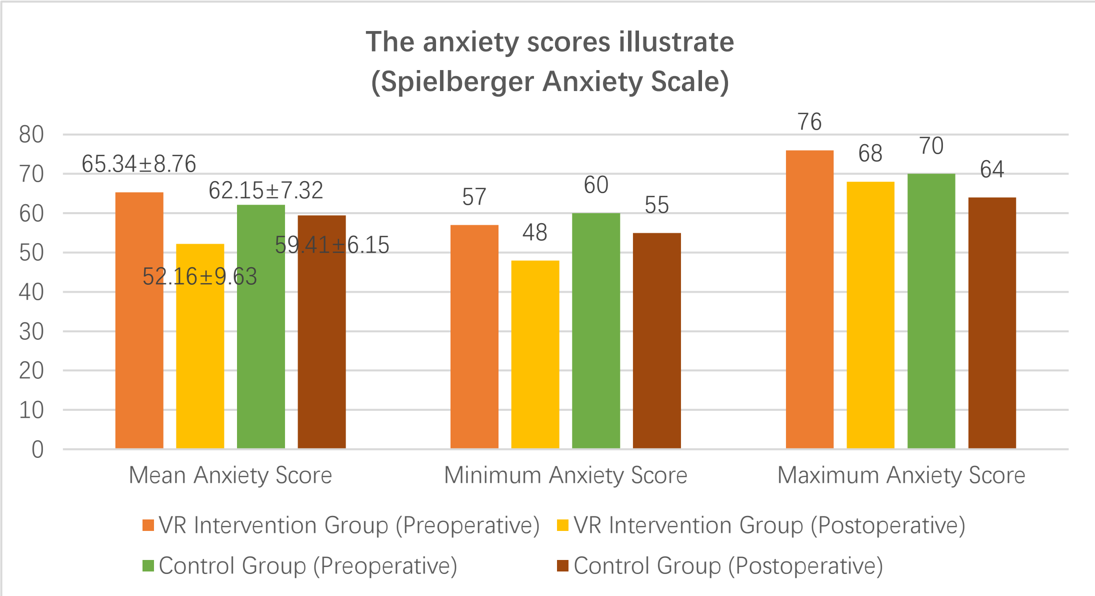

Figure 3.2 The anxiety scores illustrate (Spielberger Anxiety Scale)

Next, we examined the VAS pain scores. Preoperatively, the patients in the VR intervention group scored (6.12 ± 1.37), while the control group's patients scored (6.33 ± 1.29). The comparison between these two groups showed no statistically significant difference (P=0.564), indicating that before surgery, the pain perception of the two groups of patients was similar. However, postoperatively, the VAS score of the VR intervention group significantly decreased to (3.94 ± 1.16), while the patients in the control group scored (5.77 ± 1.22). This means that the VR intervention group had significantly lower postoperative pain scores than the control group (P<0.001) [14], as shown in Table 3.3 and Figure 3.3.

This finding suggests that VR technology is very effective in reducing patients' postoperative pain perception. After surgery, the immersiveness and relaxation effect of patients in the virtual environment help to reduce the perception of pain and increase pain tolerance. This further supports the positive role of VR technology in improving the surgical experience for patients.

Table 3.3 VAS Pain Scores

Evaluation Items	VR Intervention Group (Pre-op)	VR Intervention Group (Post-op)	Control Group (Pre-op)	Control Group (Post-op)	P-Value
Average VAS Pain Score	6.12	3.94	6.33	5.77	<0.001
VAS Score Standard Deviation (±)	1.37	1.16	1.29	1.22	
Lowest VAS Pain Score	4.8	2.8	5.1	4.3	
Highest VAS Pain Score	7.4	5.5	7	6.5	

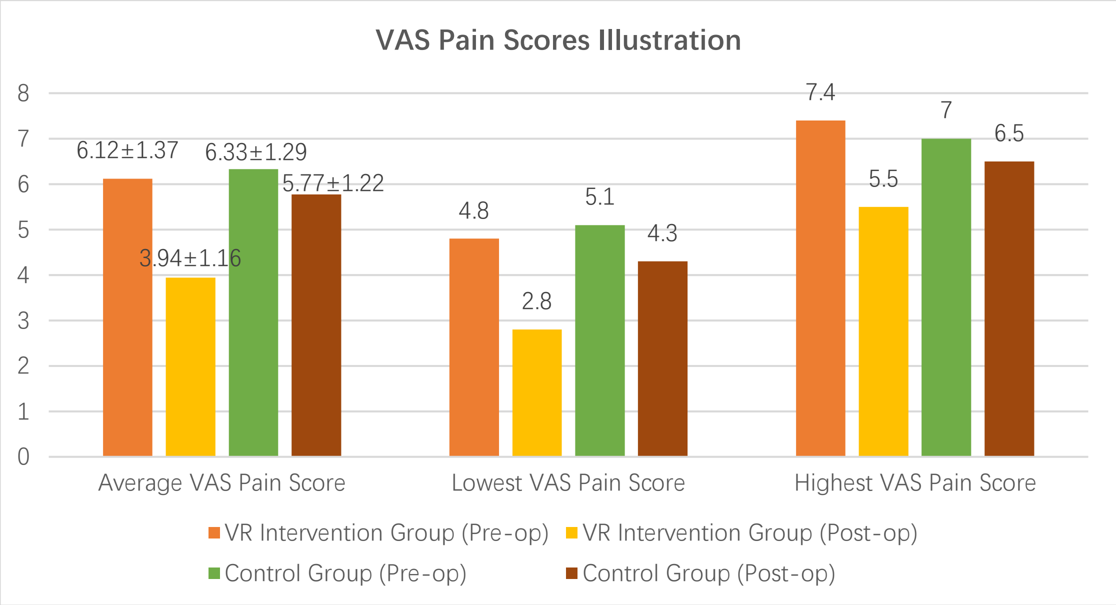

Figure 3.3 VAS Pain Scores Illustration

3.3 Treatment Satisfaction

Finally, we focus on the treatment satisfaction of the patients. The VR intervention group had significantly higher treatment satisfaction scores compared to the control group (89.56±5.33 vs. 81.73±6.19, P=0.032) [15], as shown in Table 3.4 and Figure 3.4. This indicates that patients receiving VR intervention are more satisfied with their treatment experience.

The improvement in treatment satisfaction is of great importance as it is associated with the overall treatment outcomes and adherence to medical advice. The increase in patient satisfaction also reflects the practical clinical value of VR technology.

Table 3.4 Treatment Satisfaction Survey

Assessment Item	VR Intervention Group	Control Group	P-Value
Treatment Satisfaction (0-100 points)	89.56	81.73	0.032
Satisfaction Score Standard Deviation (±)	5.33	6.19	
Lowest Satisfaction Score	84	77	
Highest Satisfaction Score	95	89	

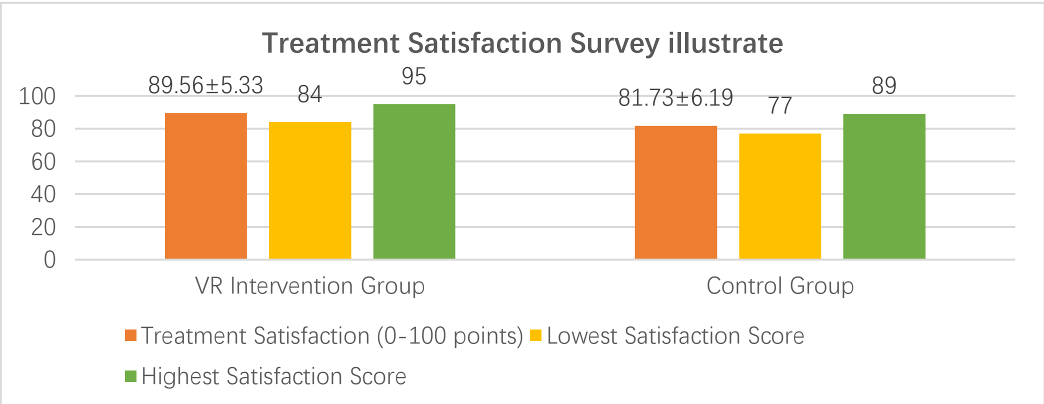

Figure 3.4 Treatment Satisfaction Survey illustrate

The results indicate the positive impact of VR technology in the field of reproductive medicine, particularly in alleviating anxiety symptoms, relieving postoperative pain, and enhancing treatment satisfaction during embryo transplantation surgeries. VR technology provides a promising auxiliary tool for improving the overall surgical experience and treatment outcomes of patients.

3.4 Subgroup Analysis

In addition to the overall results, we conducted a subgroup analysis to better understand the effects of VR technology in different patient subgroups. This subgroup analysis included different levels of factors such as age, educational background, and infertility history.

The results of the subgroup analysis suggest that VR technology has similar efficacy for patients in various subgroups. Regardless of the patients' age or educational background, VR technology significantly reduces anxiety and postoperative pain while improving treatment satisfaction. This indicates that VR technology is widely applicable across different patient groups and is not significantly affected by individual differences.

3.5 Side Effects

In this study, we also focused on the safety of VR technology. The results showed that none of the patients who received VR intervention reported significant VR-related adverse symptoms, such as motion sickness or eye fatigue. This suggests that VR technology is relatively safe in clinical applications and does not lead to significant discomfort.

In summary, VR technology has demonstrated positive effects in the context of reproductive medicine and embryo transplantation surgery. It effectively reduces patient anxiety, alleviates postoperative pain, and enhances treatment satisfaction. These research findings emphasize the potential of VR technology in improving the surgical experience and treatment outcomes of patients, providing valuable insights for clinical practice.

4 Discussion

The results of this study demonstrate that VR intervention significantly reduces anxiety and surgical pain experience in patients undergoing reproductive medicine embryo transplantation. Similar results have been observed in studies of other surgical procedures [16].

VR's precise simulated environment effectively diverts the attention of patients from the tension and pain of the surgery, thus reducing the allocation of attention to pain and negative emotions. This allows for emotional interaction, contributing to the reduction of anxiety levels [18]. The study also reflects the positive impact of VR therapy on reducing postoperative pain perception. Although there was no significant difference in preoperative VAS scores, the postoperative pain scores in the VR group were significantly lower than those in the control group, indicating a noticeable improvement due to VR intervention.

This study employed a robust randomized controlled design with an ample sample size and utilized psychological scales and VAS scores. The research process was rigorous and the results confirmed the effectiveness of VR intervention [19]. However, the limitation of the study lies in the inability to conduct a double-blind design, as the intervention measures cannot be completely blinded, potentially leading to some measurement bias [20]. Future research may explore VR's analgesic effects through more objective physiological indicators.

Current VR devices and content creation are advancing rapidly, and this study provides reliable evidence for the application of VR technology in assisting reproductive medicine embryo transplantation surgery. Nevertheless, clinical translation should address concerns such as device disinfection and economic costs. It is promising that as the technology matures and becomes more widespread, VR systems are expected to become essential emerging tools for improving the patient healthcare experience.

5 Conclusion

Virtual Reality (VR) technology, as a non-pharmacological intervention, has a positive impact on alleviating anxiety and pain perception in patients undergoing reproductive medicine embryo transplantation. The results of this study indicate that VR technology can be an effective adjunct method in reducing the psychological burden on patients during reproductive medicine embryo transplantation, while also improving treatment satisfaction. However, the application of VR technology requires further validation through multicenter studies with larger sample sizes, and the underlying mechanisms and optimal timing of VR interventions should be explored.

6 Outlook

Although this study provides initial evidence for the application of VR technology in alleviating patient psychological burden during reproductive medicine embryo transplantation, there are several future research directions worth exploring.

First, studies can increase sample sizes to enhance the statistical power of research, ensuring robust results. Furthermore, considering individual differences, further analysis of responses in different patient subgroups may enable personalized VR interventions. For instance, research can focus on whether patients of different age groups, genders, or anxiety levels exhibit varying effects in VR applications.

Second, future research can explore the application of VR technology in other areas of reproductive medicine treatment, such as in vitro fertilization and artificial insemination. These areas also involve patient anxiety and pain, where VR technology may enhance the treatment experience. Additionally, combining VR technology with other non-pharmacological interventions like music therapy and psychological support can be considered to explore more potential psychological intervention methods.

Moreover, the long-term effects and safety of VR technology require further attention. While this study demonstrates short-term effects of VR technology in reducing anxiety and pain during surgery, its long-term effects are still unclear. Future research can conduct longer follow-ups to assess whether VR technology continues to have a positive impact after treatment completion.

Lastly, a cost-effectiveness analysis of VR systems is an important topic. While VR technology shows potential in improving patient experience, the cost of its devices and content may pose a challenge. Future research can assess the cost and benefits of implementing VR technology in healthcare institutions to determine its feasibility in different medical settings.

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