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The impact of virtual reality technology in the era of See & Treat hysteroscopy: a randomised controlled trial

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ABSTRACT

Background: In the context of outpatient hysteroscopy (OPH), performing a single procedure integrating the operative and diagnostic part is known as "See & Treat hysteroscopy". The virtual reality (VR) technology provides an immersive virtual environment that can provide a non-invasive analgesic. To date, there is limited evidence regarding its use in the OPH setting.

Objectives: To evaluate the feasibility and effectiveness of VR technology for pain and anxiety management in OPH.

Methods: Unblinded, prospective, randomised controlled trial, conducted at the Hysteroscopy Unit of the University of Naples "Federico II" between May and July 2024. Women aged 18-70 years, indicated for OPH, were randomised into a control group (standard OPH care) and an intervention group (OPH care with the addition of a VR headset).

Main Outcome Measures: Pain and anxiety were assessed through subjective measures: numerical rating scale (NRS) scores before and after the procedure, and objective measures: heart and respiratory rate pre- and during the procedure. Satisfaction, time, and success rates were also evaluated.

Results: Overall, 116 women were enrolled. The VR group compared to the control group reported significantly lower mean standard deviation NRS scores for pain [3.9 (2.7) vs. 5.4 (3.0); mean difference 1.5, 95% confidence interval (CI) 0.4 to 2.5] and anxiety [3.2 (2.1) vs. 4.8 (2.8); mean difference 1.6, 95% CI 0.7 to 2.5] respectively. Regarding satisfaction, 96.5% of the VR group would use the headset again, whereas 3.5% requested its removal. All women in the control group desired a distraction. No serious adverse events were reported.

Conclusions: VR technology proved feasible and effective for pain and anxiety management in OPH, particularly during operative procedures.

What is New? Its use can support the implementation of the See & Treat philosophy.

Keywords: Outpatient hysteroscopy, virtual reality technology, pain and anxiety

Introduction

Hysteroscopy is a minimally invasive endoscopic technique that is considered the gold standard for diagnosing and treating intracavitary lesions.[1]

Technological advancements, including the introduction of miniaturised instruments and the vaginoscopic approach, have led to an increase in the number of diagnostic and operative hysteroscopic procedures performed in an outpatient hysteroscopy

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(OPH). In this context, the "See & Treat hysteroscopy"[2] approach, which integrates the operative part into the diagnostic work-up in a single procedure, has several advantages, such as reduced hospital stays, shorter recovery times, greater compliance, improved patient satisfaction, and a better cost-benefit ratio, while avoiding the risks associated with anaesthesia.[3-5] Although See & Treat hysteroscopy is generally well-tolerated,[6] it can cause physical and emotional discomfort for some patients, leading to acute pain and anxiety; the anxiety and concern felt by women before and during the procedure can impact the perception of pain and the tolerability of the exam, potentially causing the procedure to fail.[7,8]

Common pain relief options during hysteroscopy include sedation, injectable local anaesthetics, and analgesics,[9-11] but the quality of evidence from studies supporting these methods is poor.[12] Therefore, there is a need to identify new pain control strategies that are alternative or complementary to pharmacological analgesia. One emerging strategy is the use of virtual reality (VR) technology, which has been increasingly studied and utilised in various medical fields for pain and anxiety management.[13-16]

VR technology provides a realistic, immersive virtual environment usually viewed through a headset, which can interactively produce a non-invasive analgesic condition that helps alleviate pain and anxiety.[16] Studies have shown promising results in several fields, including surgical training, patient education, rehabilitation, pain and anxiety management for a variety of scenarios, including burns treatment, medical and paediatric procedures, hysterosalpingography, dentistry, chronic pain, orthopaedic procedures, labour, episiotomy and phobias.[17-23]

To address the scarcity of scientific evidence on the use of VR technology, considering its potential as a supportive non-pharmacological anaesthetic technique during office gynaecological procedures and in the hysteroscopic field, this study aimed to evaluate the feasibility and effectiveness of using VR technology to improve pain and anxiety management during OPH compared to standard care, and to increase the acceptability of the 'See & Treat' philosophy.[24-30] Additionally, patient questionnaires and vital parameter recordings were used to obtain both subjective and objective criteria to ensure unbiased results.

Methods

An unblinded prospective randomised controlled trial was conducted at the Hysteroscopy Unit of University of Naples "Federico II", from May to July 2024. The study was approved by the Ethics Committee of the Campania Region (protocol N°: 112/2024, minutes N°: 7/24, dated: 14 May 2024).

Patients aged 18-70 years old, undergoing OPH for any indication, who provided informed consent to participate in the study and provided informed consent were included. The exclusion criteria included history of epilepsy, severe vertigo, neurodegenerative diseases (for example amyotrophic lateral sclerosis, multiple sclerosis), neuropathic pain (for example diabetic neuropathy), chronic pain (for example fibromyalgia), paralysis of the lower limbs, vulvodynia and vaginismus, significant visual or hearing impairment and predisposition to motion sickness, contraindications for hysteroscopic examination.

Eligible women were randomly assigned to the intervention VR or control group (1:1 ratio), using an online tool for randomisation.[15,16] Blinding of participants or researchers was not possible due to the nature of the intervention involving the use of a headset; however, randomisation and data analysis were performed by a separate member of the research team to minimise selection bias.

All procedures were carried out in an outpatient setting, using a vaginoscopic approach with a 5 mm Bettocchi continuous flow operating hysteroscope (Karl Storz, Germany), without analgesia or anaesthesia. Uterine cavity distension was achieved with a saline solution using the "Hamou Endomat®" pump (Karl Storz, Germany); the mean intrauterine pressure was constant at 30-40 mmHg, with a flow rate of 220-350 mL/min, an irrigation pressure of 75-100 mmHg and a suction pressure of 0.25 bars.

5 Fr mechanical instruments and bipolar electrodes, 15 Fr bipolar office resectoscope (Karl Storz, Germany) and Truclear™ Elite Mini tissue removal devices (Medtronic) were used to treat endouterine lesions. All procedures were performed by two experienced gynaecologists (A.D.S.S. and B.Z.).

In the control group, patients underwent OPH with our standard care, while in the VR group, patients received standard care along with VR therapy provided via a VR headset and headphones with hypno VR software [Deepsen VRx Device, Deepsen, DT Didier, Mont d'Or,

France (http://www.deepsen.io/)] (Figure 1). The headset transported women in a relaxing environment chosen according to the patient's preference from a range of options (mountain, hill, river). The headphones provided an audio-guided breathing exercise on a background of pleasant relaxing music.

This virtual scenario was developed with specialised psychologists to obtain an attentive shift, reducing procedure-related pain and anxiety. The headset was controlled by a researcher present in the ambulatory unit, and the operator could adjust the duration of the virtual projection to cover the expected length of the entire procedure. The patients could ask to stop the video or remove the headset at any point during the procedure.

Primary outcome measures were:

- Level of pain and anxiety reported by the patient, expressed on a 10-point numerical rating scale (NRS), from 0 indicating no pain or anxiety, to 10 corresponding to the worst pain or anxiety (subjective criteria), during diagnostic and operative procedures.

- Heart rate (HR) and respiratory rate (RR), collected by a dedicated nurse before and during diagnostic and operative procedure (objective criteria).

Figure 1. Virtual reality headset *(Deepsen VRx Device, Deepsen, DT Didier, Mont d'Or, France).*

Secondary outcome measures were:

- Procedure completion and suspension rate (defined as the proportion of suspended procedures for any reason),

- Time of procedure,

- Satisfaction rate (VR group: desire to use the headset again in the future/control group: desire to use the headset if they could),

- Reported side effects.

Participants completed pre- and post-procedure questionnaires, sharing data on pain and anxiety levels before and after the examination. In the pre-procedure questionnaire, patients were asked about the NRS scores for anticipated average pain and anxiety about the procedure. In the post-procedure questionnaire, instead, it was collected the NRS scores for average pain and anxiety felt during the procedure were collected. Data on women's age, body mass index, obstetric history, menopausal status, previous hysteroscopies, and indication for the exam were collected before the procedure.

Statistical Analysis

For categorical variables, data were presented as absolute values and incidence rates. For continuous variables, data were presented as mean and standard deviation (SD). Means and SDs were calculated for normally distributed data, and comparisons were made with the unpaired Student's t-test. A post-hoc analysis was performed using analysis of covariance (ANCOVA) to test the robustness of the finding after controlling for baseline pain and anxiety levels. Statistical analyses were conducted using the Statistical Package for Social Sciences (SPSS) software (IBM Inc., Armonk, NY, USA), with significance set at $P \leq 0.05$.[31]

Results

During the recruitment period, 178 women undergoing a procedure at our hysteroscopy unit met the inclusion/exclusion criteria; 116 out of 178 (65.16%) agreed to participate in the study and were randomised (1:1) into one of the two study groups (Figure 2). The baseline characteristics of the patients are shown in Table 1. Fifty-eight patients were randomised to the VR group and fifty-eight to the control group. Neither local anaesthetic nor additional analgesic or anti-emetic drugs were administered during the procedure in either group.

The most common indication for the examination was incidental abnormal ultrasound findings (e.g., endometrial thickening, suspected polyps, or fibroids). Both diagnostic and operative procedures were performed; 40 out of 58 procedures (68.9%) were operative in the VR group and 34 out of 58 (58.6%) in the control group (*P*=0.68). Operative procedures were endometrial biopsy, polypectomy, myomectomy, adhesiolysis and metroplasty.

Thirty-five out of 58 (60.3%) women in the VR group and 38 out of 58 (65.5%) in the control group were undergoing hysteroscopic examination for the first time. Four patients (6.9%) in the VR group and only 2 patient (3.4%) in the control group had cervical stenosis; two patients asked to remove the visor before the end of the procedure in the VR group (suspension rate: 2/58); both suffered from panic attacks and did not enjoy the VR experience.

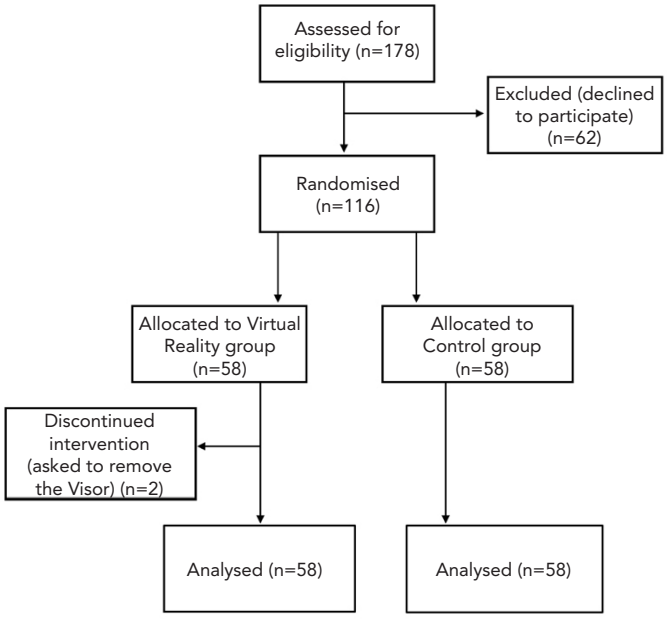

Figure 2. Consort flow diagram.

Levels of perceived pain and anxiety during the procedures were significantly lower in the VR group than in the control group; statistically significant differences in mean NRS scores for expected (pre-procedure) and perceived (post-procedure) pain and anxiety were found in the VR group compared with the control group (Table 2). When analysing NRS post-procedure scores and the mean difference in NRS scores for pre- and post-procedure pain separately for diagnostic and operative procedures, we found that perceived pain and anxiety were significantly lower in the control group compared to the VR group, but only for operative procedures. In contrast, for diagnostic procedures, these differences did not reach statistical significance (Supplementary Tables 1 and 2).

Differences between the 2 groups regarding objective parameters were not significant. After checking for normality, post-procedure anxiety and pain scores were found to be normally distributed, and the comparison of averages was performed with Student's independent t-test.

Regarding secondary outcomes, 100% of the procedures were completed in both study groups (Table 2). No serious side effects or procedure-related complications were reported in either group. However, the VR headset group, two patients reported mild nausea that did not require anti-emetics. In the control group, one patient reported a presumed vasovagal episode, which never occurred in the VR group, despite the use of the headset. Regarding satisfaction rate, 56/58 women (96.5%) would use the headset again in the future; 2/58 women (3.5%) instead asked to remove the visor before the end of the procedure. 58/58 (100%) women in the control group would like to use a source of distraction during the procedure if they could.

Table 1. Participant baseline characteristics.

Characteristics	Virtual reality group (n=58)	Control group (n=58)
Age (mean, SD)	45.00 (13.00)	43.24 (11.26)
BMI (mean, SD)	26.39 (5.11)	25.20 (5.64)
Previous CS (n, %)	14/58 (24.13%)	13/58 (22.41%)
Previous vaginal delivery (n, %)	20/58 (34.48%)	18/58 (31%)
Premenopausal (n, %)	41/58 (70.69%)	42/58 (72.41%)
Postmenopausal (n, %)	17/58 (29.31%)	16/58 (27.59%)
First hysteroscopy	35/58 (60.3%)	38/58 (65.5%)

SD: Standard deviation, BMI: Body mass index, CS: Caesarean section.

Table 2. Primary and secondary outcomes measures for both diagnostic and operative procedures.

Primary outcomes	**Virtual reality group (n=58)**	**Control group (n=58)**	**Difference of means (95% CI)**	***P*-value**
NRS score for post-procedure pain (mean, SD)	3.92 (2.70)	5.41 (2.98)	1.49; 95% CI 0.44 to 2.53	***P* 0.005**
Mean difference in NRS scores for pre- and post- procedure pain (mean, SD)	-2.48 (2.95)	-0.10 (3.06)	2.28, 95% CI 1.27 to 3.48	***P*<0.0001**
NRS score for post-procedure anxiety (mean, SD)	3.21 (2.13)	4.84 (2.79)	1.63; 95% CI 0.71 to 2.54	***P* 0.0006**
Mean difference in NRS scores for pre- and post- procedure anxiety (mean, SD)	-3.01 (2.55)	-1.00 (2.07)	2.1, 95% CI 1.24 to 2.95	***P*<0.0001**
HR during procedure (mean, SD)	85.35 (11.35)	88.68 (15.02)	3.30; 95 %CI -1.56 to 8.22	*P*=0.18
RR during procedure (mean, SD)	19.19 (4.60)	18.77 (3.69)	0.42; 95% CI -1.95 to 1.11	*P*=0.58
Secondary outcomes	VR group (n=58)	C group (n=58)	Difference of means (95% CI)	***P*-value**
Length of procedure, minutes	6.94 (4.49)	5.91 (3.32)	-1.03 95% CI -2.48 to 0.42	*P*=0.16
Satisfaction rate (VR group: would use the headset again in the future/C group: would like to use it if they could) (n, %)	56/58 (96.5%)	58/58 (100%)	-	-
Side effects (nausea, vasovagal episode) (n, %)	2/58 (3.45%)	1/58 (1.72%)	-	-
Incomplete procedures (n, %)	0/50	0/50	-	-

CI: Confidence interval, SD: Standard deviation, NRS: Numerical rating scale, HR: Heart rate, VR: Virtual reality.

Discussion

In the era of See & Treat procedures, in which nearly 90% of all hysteroscopic surgeries can be performed in outpatient setting, the major challenge is to minimise the physical and emotional discomfort of the patient; worry and anxiety increase the perception of pain and limit the tolerability of the exam, sometimes leading to the failure of the procedure itself. Therefore, reducing the patient's anxiety ensures a better result and a higher level of satisfaction.

Hence, there is a need to identify new alternatives for pain control strategies, ranging from emotional support provided by dedicated healthcare personnel ("vocal anaesthesia") to more recent visual and auditory sources of entertainment (such as music, videos), including VR.[12] To date, VR has been widely used in medicine, but there is still limited and conflicting data in the literature regarding its use in gynaecological and particularly hysteroscopic fields.

The mechanism through which VR acts is known as "distraction analgesia", where immersion in a virtual environment diverts the patient's attention from painful stimuli. This process is rooted in Melzack's[32] theory of "neuromatrix of pain", which states that pain is a multidimensional experience, generated in the brain by the particular and individual organisation of nervous stimuli, modified by sensory experience. Sensory distraction, therefore, leaves fewer resources for pain processing and shifting attention from unpleasant feelings to attractive or pleasant stimuli can help avoid negative mood states such as stress and anxiety.[32]

A meta-analysis revealed that VR may play a role in reducing pain scores in acutely painful procedures but was shown to be effective only in needles and burns physical therapy. However, it was limited by the clinical and statistical heterogeneity of the studies.[21]

Our findings suggest that the use of VR technology during OPH significantly reduces the subjective perception of pain and anxiety. In fact, Patients in the VR group experienced significantly less pain and anxiety during the procedure compared to the control group, with significant differences in expected pain and anxiety scores compared to perceived pain and anxiety scores. Subgroup analysis suggested this result was particularly

true for operative procedures. These results are highly relevant for the broader adoption of See & Treat procedures, allowing to perform most of the operative hysteroscopy in the outpatient setting without the need for an operating room, reducing the waiting list.

These data agree with the original work of Deo et al.[24], which reported a significant reduction in pain and anxiety while disagreeing with a recent study of Sewell et al.[27], which found no statistical difference in pain scores, only lower patient-reported anxiety during the procedure. Estadella Tarriel et al.[33] emphasised how VR can have a highly beneficial impact on pain and anxiety management associated with hysteroscopy. However, as a standard practice in their centre, all patients receive ibuprofen and diazepam 30 minutes before the procedure. In our study, we opted not to use any premedication to avoid influencing pain perception and to ensure the reliability of the collected data.[32] Notably a study by Pelazas-Hernández et al.[34] demonstrated a significantly positive impact of VR on both pain and anxiety, although they assessed only diagnostic hysteroscopies.

We also collected patients' vital parameters to obtain objective measures of pain and anxiety.[34]

The maximum HR recorded during the procedure was higher in the control group than in the VR group (although statistical significance was achieved only in the analysis of diagnostic procedures), suggesting that the distraction mechanism may, in certain categories of patients, help the patient in anxiety management.

In contrast, no difference was found in RR. These results are partially in disagreement with an earlier study by Fouks et al.[26] that reported an increase in HR of patients wearing headphones, but with no significant difference in patient-reported pain.

Our findings also indicate that VR technology is feasible without any significant increase in side effects or in procedure failure, or the length of the procedure.

Our study is among those with the largest sample size currently conducted on the use of VR in OPH; the baseline characteristics of the study population were well matched in terms of age, parity, and menopausal status, and they were randomly allocated to the two groups. Additional strengths include the fact that it was representative of the full range of procedures performed in our OPH department.

However, the lack of blinding could influence the patient-reported pain and anxiety scores and the heterogeneity of the procedures could influence the strength of conclusions, although the number of operative procedures was the same in the two groups. Another potential weakness is the lack of stratification of the groups based on the patients' anxiety status prior to the procedure. For instance, there could be more "anxious patients" in one group compared to the other. We hope that randomisation minimises the impact of any potential bias, but this aspect should be included as a possible limitation.

Conclusion

VR technology appears to be a feasible and effective technique as a distraction method in OPH for pain and anxiety management, particularly during operative rather than diagnostic procedures. This technological tool could facilitate the implementation and wider acceptance of the 'See & Treat' philosophy. Our data encourages further studies, which, by increasing the sample of patients undergoing outpatient operative hysteroscopies, could confirm the usefulness of VR technology and persuade doctors and patients to the increasing uptake of the outpatient approach, with all its associated advantages.

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Ethical approval: The study was approved by the Ethics Committee of the Campania Region (protocol N°: 112/2024, minutes N°: 7/24, dated: 14 May 2024).

Informed consent: Patients aged 18-70 years old, undergoing OPH for any indication, who agreed to participate in the study and provided informed consent were included.

Data sharing: The data that support the findings of this study are available from the corresponding author upon reasonable request. Restrictions apply to the availability of these data due to confidentiality agreements and the sensitive nature of patient information.

Transparency: The authors affirm that this manuscript is an honest, accurate, and transparent account of the cases reported. All relevant details have been included, and no important information has been omitted. The patients' identities have been protected in accordance with ethical standards.

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Supplementary Table 1. Primary and secondary outcome measures for diagnostic procedures.

Primary outcomes	**Virtual reality group (n=18)**	**Control group (n=24)**	**Difference of means (95% CI)**	***P*-value**
NRS score for post-diagnostic procedures pain (mean, SD)	4.21 (2.87)	4.66 (2.58)	-0.45; 95% CI -1.25 to 2.15	*P*=0.59
Mean difference in NRS scores for pre- and post-procedure pain (mean, SD)	-2.89 (3.12)	-1.25 (3.22)	-1.64 95% CI -3.64 to 0.36	*P*=0.10
NRS score for post-procedure anxiety (mean, SD)	3.21 (2.27)	4.75 (3.02)	-1.54 95% CI -3.2 to 0.17	*P*=0.07
Mean difference in NRS scores for pre- and post-procedure anxiety (mean, SD)	-2.36 (2.71)	-1.12 (1.4)	-1.24 95% CI -2.72 to 0.24	*P*=0.10
HR during procedure (mean, SD)	83.47 (9.29)	88.58 (14.02)	-5.11 95% CI -2.6 to 12.8	*P*=0.18
RR during procedure (mean, SD)	18.94 (4.41)	18.29 (3.73)	0.65 95% CI 3.19 to -1.89	*P*=0.60
Secondary outcomes	**VR group (n=18)**	**C group (n=24)**	**Difference of means (95% CI)**	***P*-value**
Length of procedure, minutes	3.84 (1.30)	4.75 (4.25)	0.91 (95% CI -1.18 to 3)	*P*=0.38
Satisfaction rate (VR group: would use the headset again in the future/C group: would like to use it if they could) (n, %)	18/18	24/24	-	-
Side effects (nausea, vasovagal episode) (n, %)	0/18	0/24	-	-
Incomplete procedures (n, %)	0/18	0/24	-	-

CI: Confidence interval, SD: Standard deviation, NRS: Numerical rating scale, HR: Heart rate, RR: Respiratory rate, VR: Virtual reality.

Supplementary Table 2. Primary and secondary outcome measures for operative procedures.

Primary outcomes	**Virtual reality group (n=40)**	**Control group (n=34)**	**Difference of means (95% CI)**	***P*-value**
NRS score for post-procedures pain (mean, SD)	3.78 (2.63)	5.32 (2.98)	-1.54 95% CI -2.84 to -0.23	*P*=0.02
Mean difference in NRS scores for pre- and post- procedure pain (mean, SD)	-2.27 (0.70)	-0.5 (2.75)	-1.77 95% CI -2.66 to -0.87	*P*=0.0002
NRS score for post-procedure anxiety (mean, SD)	3.21 (2.48)	4.91 (2.65)	-1.7 95% CI -2.89 to -0.5	*P*=0.005
Mean difference in NRS scores for pre- and post- procedure anxiety (mean, SD)	-3 (3)	-1.35 (2.41)	-1.65 95% CI -2.92 to- 0.37	*P*=0.01
HR during procedure (mean, SD)	86.32 (12.27)	88.52 (15.68)	2.2 95% CI -4.28 to 8.68	*P*=0.5
RR during procedure (mean, SD)	19.32 (4.76)	19.11 (3.68)	-0.21 95% CI -2.20 to 1.78	*P*=0.83
Secondary outcomes	**VR group (n=40)**	**C group (n=34)**	**Difference of means (95% CI)**	***P*-value**
Length of procedure, minutes	8.54 (4.72)	6.91 (2.42)	-1.63 (95% CI -3.41 to 0.15)	*P*=0.07
Endometrial biopsy, time	*(n=11)* *7.45 (±3.75)*	*(n=11)* *6.3 (±2.31)*	-1.15(95% CI -3.9201 to 1.6201)	*P*=0.39
Endometrial polypectomy, time	*(n=12)* *8 (±3.33)*	*(n=10)* *8.0 (±2.12)*	0 (95% CI 2.5453 to 2.5453)	*P*=1
Cervical polypectomy, time	*(n=8)* *5.42 (±0.78)*	*(n=7)* *5.85 (±2.41)*	0.43 (95% CI -1.5093 to 2.3693)	*P*=0.63
Myomectomy, time	*(n=2)* *13.5 (±9.19)*	*(n=2)* *11 (±1.41)*	2.5 (95% CI -30.7872 to 25.7872)	*P*=0.74
Metroplastic, time	*(n=3)* *11.66 (±4.04)*	*(n=4)* *6.5 (±1.29)*	-5.16 (95% CI -10.5465 to 0.2265)	*P*=0.0571
Synechiolysis, time	*(n=4)* *13.5 (±6.75)*	*(n=0)* -	-	-
Satisfaction rate (VR group: would use the headset again in the future/C group: would like to use it if they could) (n, %)	38/40 (95%)	34/34 (100%)	-	-
Side effects (nausea, vasovagal episode) (n, %)	2/40 (mild nausea) (5%)	1/34 (vasovagal episode) (2.94%)	2.06 % (95% CI -10.44% to 13.81%)	*P*=0.65
Incomplete procedures (n, %)	0/40	0/34	-	-

CI: Confidence interval, SD: Standard deviation, NRS: Numerical rating scale, HR: Heart rate, RR: Respiratory rate, VR: Virtual reality.