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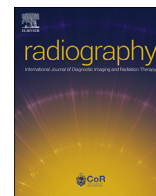
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# Effects of a 360° virtual counselling environment on patient anxiety and CCTA process time: A randomised controlled trial

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## ARTICLE INFO

## ABSTRACT

Introduction: This study investigated whether a 360° virtual counselling environment (360°VCE) was more effective at decreasing patients' anxiety than routine standard of care counselling for patients undergoing coronary computed tomography angiography (CCTA), and if there was any difference in the process times for both of these groups.
Methods: A total of 86 patients underwent CCTA in this randomised controlled trial. Patients were randomly assigned to intervention and control groups. The 360°VCE was developed using spherical panoramic images and non-immersive 360° technology. The primary outcome, anxiety, was measured using the State-Trait Anxiety Inventory (STAI). The secondary outcome, CCTA process time, was measured from the time of arrival in the department until end of examination.
Results: Pre-scan anxiety was lower among patients in the 360°VCE group immediately before CCTA in comparison to patients in the control group ($p = 0.015$). Women demonstrated higher levels of anxiety than men in both groups. No between-group differences were discerned in CCTA process time.
Conclusion: Access to 360°VCE can reduce patients' pre-CCTA anxiety levels.
Implications for practice: The presented results can be used to improve patient counselling and care, reduce anxiety among patients undergoing CCTA, and optimise the CCTA examination procedure.

## Introduction

It is essential to provide patients with adequate information and counselling before imaging procedures to increase their understanding of the process and help manage anxiety.[1–3] Medical imaging-related anxiety has received previous research attention (Table 1), and is recognised as a regular occurrence.[2,4,5]

Coronary artery disease is diagnosed by coronary angiography or coronary computed tomography angiography (CCTA).[85–87] Electrocardiogram (ECG)-gating during CCTA aligns the imaging sequence with the patient's heartbeat. This minimises motion artefacts, improves image resolution and reduces the radiation dose.[88–90] However, anxiety during CCTA can reduce patient safety,[11] the quality of the imaging experience[44] the image quality, as well as increase the radiation dose.[10,13] Hence, focusing on the quality of counselling could prevent pre-cancellations and repeated scans.[2] Informing the patient about the imaging procedure can also improve knowledge, the sense of security, empowerment and self-efficacy, and spatial or environmental orientation to decrease some potential adverse effects.[1,91,92] It is notable that awareness about the importance of patient-centred counselling has increased,[93] with patient-centred care and evidence-based practices for improving the quality in clinical practice recently identified as research priorities for radiography science.[94]

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**Table 1**
Previous research on medical imaging-related anxiety.

| Imaging modality, where evaluated | Studies |
|---|---|
| CT | 6—16 |
| MRI | 17—43 |
| Angiography | 44—49 |
| Plain X-ray | 50—52 |
| Mammography | 35,36,38,39,53—61 |
| Nuclear medicine | 33,62—71 |
| Imaging in general | 72,73 |

| Background factors related to anxiety | Studies |
|---|---|
| Female gender | 7,8,13,14,23,24,29,31,45,67,72,74—77 |
| First-time in the imaging examination | 4,5,8,65,72,75,76,78 |
| Age | 8,15,38,39,55,57,61,72,76 |
| Level of education | 4,36,56,72,77 |
| Smoking | 4,6,54,56,67 |
| High BMI | 9,54 |
| Diabetes | 9 |
| Use of intravenous contrast media | 76 |

| Factors causing medical imaging-related anxiety | Studies |
|---|---|
| The patient's clinical situation and concern about the examination result | 4,4,5,7,8,14,18,63,66,69,72,73,75,76,79—83 |
| Examination procedure | 8,33,66,69,72,73,75,82 |
| Pain | 49,50 |
| Claustrophobia | 7,73,76,80,82 |
| Intravenous cannulation or contrast media | 7,8,69,76,82 |
| Radiation | 7,8,62,69,76,78,82,84 |
| Previous negative experiences | 76,81 |

Abbreviations: CT — computed tomography; MRI — magnetic resonance imaging; BMI — body mass index.

A total of five previous studies have analysed CCTA-related anxiety (Table 2). Notably, 50—74% of patients experienced anxiety before the CCTA.[7,9] Pre-CCTA[11] multimedia education and enhanced counselling[10] were found to relieve anxiety and improve image quality.[11]

Traditionally, counselling for medical imaging is provided in written format, which may be misunderstood and misinterpreted.[78,80,95—97] The use of digital technologies in counselling enables the simultaneous provision of written, verbal, and visual information, a feature which has been desired by patients.[18,72,78,98—102]

Novel digital technologies, such as virtual reality (VR), have become increasingly available to consumers. The definitions of VR vary significantly; a recent trend in VR experiences is 360° technology,[103] which is abbreviated as 360VR and can offer consumers 360° videos of a certain setting.[104] High-immersion solutions allow a user to view the full panorama with a head-mounted VR display, whereas low-immersion solution allow a user to view the 360° panorama content by moving or rotating a device, e.g., a personal computer, smartphone, or tablet.[103] Various previous reviews[104,105] have described how VR can be used as a supportive tool in health care, and have emphasised how this technology can replicate the real world as a preparatory and familiarity technique.[52,104,105] In the radiography context, VR interventions have been used in MRI,[106—112] PET/CT,[63] plain radiography[51,52,113] and ultrasound.[113] Most VR interventions have been developed for paediatric patients,[51,52,106,107,109,112,113] while 360° technology-based counselling has been evaluated in four previous studies[51,52,107,109] (Table 3).

However, 360° environments have limited applications in adult patients and the CT context. Nevertheless, 360° environments have improved both the accessibility and ease of care[114] and have allowed patients to practice and experience the medical imaging procedure repeatedly prior to arriving for their appointment.[22]

This study focuses on a novel 360° virtual counselling environment (360°VCE) that is based on spherical panoramic images and low-immersion 360° technology. The solution is both time- and place-independent, which may encourage the use of the application. The 360° feature enables patients to encounter the CCTA environment, access relevant information and familiarise themselves with the procedure at their own pace.[1,108]

To the best of our knowledge, this is the first study that focuses on the benefits of VR and 360°-environments for counselling adult CCTA patients. The results can help medical imaging professionals better understand why patients experience CCTA-related anxiety and identify appropriate methods for decreasing anxiety levels among patients.

Our study aimed to investigate how effective a 360°VCE is at reducing patients' anxiety levels and improving CCTA process time (measured from the time of arrival in the department until end of examination).

## Method

### Study design

The presented research represents a randomised controlled parallel trial (clinical trial NCT03677791). Participants were randomly assigned — at a 1:1 ratio — into two groups: an intervention (360°VCE) group and a control group. The reported results follow the CONSORT statement,[115] with the CONSORT and Tidier checklists presented in Multimedia Appendices 1—2.

### Participants

The participants were recruited from one university hospital in Finland between May 2020 and May 2022. Eligibility criteria were (a) had their first CCTA; (b) were over 18 years of age; (c) were mentally capable participating; and (d) were capable of independently using the 360°VCE and participating in the study. Eligible patients (Fig. 1) with a scheduled CCTA were identified from the

**Table 2**
Aims, settings, and findings of prior research related to CCTA anxiety.

| Study | 1 (ref. [7]) | 2 (ref. [9]) | 3 (ref. [10]) | 4 (ref. [11]) | 5 (ref. [13]) |
|---|---|---|---|---|---|
| Aim of the study | To analyse the causes of anxiety among patients undergoing CCTA and to determine which patient-related factors this anxiety is correlated with | To evaluate the prevalence, severity, and impact of scanxiety on quality and interpretability of CCTA. | To compare the effects of different CTA nursing methods on CCTA patients' anxiety | To explore the value of multimedia education and nursing interventions for CCTA patients | To evaluate the psychological state and anxiety of patients undergoing CCTA |
| Setting | Cross-sectional study | Cohort study | RCT, two groups: psychological counselling and routine counselling | RCT, two groups: multimedia counselling and routine counselling | cross-sectional study |
| Sample size | 325 | 344 | 100 | 120 | 442 |
| Country | Germany | Canada/France | China | China | Italy |
| Time period | 2012–2014 | 2016–2017 | 2013–2018 | 2019–2020 | 2008–2010 |
| Scale | Self-developed instrument | IES-6, Visual stress scale | SAS | SAS | EMAS |
| Main results | 47.3% of patients (n = 146) reported anxiety before CCTA. Women were more likely to have anxiety than men (60.0% vs. 39.1%, $p < 0.005$). Causes of anxiety: potential diagnosis of CAD, claustrophobia, fear about the administration of contrast material, radiation, fear of intravenous needle placement | 74.1% (n = 255) of patients reported some scan-related distress, with a mean IES-6 score of $4.1 \pm 4.3$ (range 0–18). Lower BMI was associated with lower anxiety levels ($26.4 \pm 4.3$ vs $27.7 \pm 5.1$, $p = 0.02$). No significant correlations between either image quality or heart rate variability and anxiety were reported. | Psychological counselling reduced heart rate, diastolic blood pressure and systolic blood pressure scores of patients in the observation group relative to the control group ($p < 0.05$). Similarly, the intervention group showed lower anxiety levels than the control group (SAS $54.43 \pm 4.34$ $-27.17 \pm 2.04$ vs $53.79 \pm 4.03$ $-33.51 \pm 3.38$; $p < 0.05$). Psychological counselling improved image quality ($p < 0.05$). | Multimedia counselling decreased heart rate and blood pressure compared to the routine counselling ($p < 0.05$). The group that had received multimedia counselling demonstrated lower anxiety scores than the routine counselling group (SAS $53.6 \pm 6.2$ $-37.3 \pm 4.6$ vs $54.9 \pm 6.7$ $-48.5 \pm 4.3$; $p < 0.05$). Multimedia counselling improved image quality ($p < 0.05$) and reduced the incidence of adverse reactions ($p = 0.031$). | Anxiety was higher pre-scan (EMAS 51.7 vs. 46.7, $p < 0.01$). Women demonstrated more intense anxiety (EMAS score 59.5 vs. 47.3, $p < 0.01$), higher mean heart rate ($63.5 \pm 7.6$ vs. $60.7 \pm 7.3$ beats per minute, $p < 0.01$), and lower image quality than men ($p < 0.0001$). |

patient information system by the first author. All of the participants received an informed consent form as well as an invitation letter that included relevant information and the baseline questionnaire.

Sample size calculation was based on power analysis and Spielberger's STAI.[116] According to previous studies, 40–75% of CCTA patients feel anxious,[7,9] while a counselling intervention reduces anxiety by 30–50%. The power analysis was based on those previous studies[7,9] and assumed that 360°VCE decreases anxiety by 30%. Analysis included an alpha value 0.05 and a beta value of 0.20, suggesting that each group should include 41 patients, for a total of 82 patients.

### Randomisation and blinding

Patients who had provided consent were advised to complete the baseline questionnaire and then contact the study assistant for randomisation. The assistants who performed the randomisation did not participate in the other study phases. A biostatistician who was not involved in clinical care prepared the random allocation list using a computerised random number generator. Each group was also stratified by gender and age using random permuted blocks (block size 4). It was not possible to blind the participants due to the nature of the intervention. Other than the applied intervention (360°VCE or counselling), the groups were treated identically. Radiology department personnel were blinded. The first author analysed the data and was aware of the group allocation.

### Interventions

Once the participants were randomised, the assistant gave instructions depending on the participant's allocation; more specifically, members of the standard care group received an informational letter and oral counselling, while members of the 360°VCE group received an informational letter, oral counselling, along with a link to the 360°VCE (Fig. 2) described in a previous study[1] and a video (Fig. 3) https://youtu.be/d2XzFj8Uy_U. The 360°VCE was opened two weeks before the CCTA appointment and closed six months after.

### Ethical considerations

This study adhered to the World Medical Association Declaration of Helsinki. The study was approved by the Oulu University Hospital and Oulu University Hospital Regional Ethics Committee and was registered to ClinicalTrials.gov (NCT03677791). Participation was voluntary, and participants were informed in writing form. Participants signed their written informed consent before participation. Data was collected and stored securely in a locked room in password protected computer and accessed only by the first author. The data will be deleted in the end of year 2022. Participants were informed about the anonymisation of the results.

### Outcome assessment

The primary outcome was anxiety, while the secondary outcome was CCTA process time (measured from the time of arrival in the department until end of examination). Baseline anxiety (at home, before randomisation) was measured through the self-assessed STAI questionnaire[116] that was sent to participants by mail. Anxiety was re-measured at the department immediately before the CCTA using the same questionnaire, and CCTA process times were gathered from the radiological information system.

**Table 3**
The aims, settings, and findings of previous studies related to 360°VR counselling.

| Study | 1 (ref. 109) | 2 (ref. 51) | 3 (ref. 52) | 4 (ref. 107) |
|---|---|---|---|---|
| Aim of the study | To develop a VR resource to prepare paediatric patients for MRI and help reduce anxiety in children undergoing the procedure | To evaluate whether VR education for paediatric patients before chest radiography could reduce anxiety and distress, as well as improve the radiographic process | To evaluate the effect of VR, compared with standard video, on reducing anxiety and distress in paediatric patients undergoing chest radiography. | To compare the effectiveness of a VR-based simulation app and the standard preparatory manual and a hospital-based Child Life Program on success and anxiety during a simulated paediatric MRI scan. |
| Setting | cross-sectional study | RCT, two groups | RCT, two groups | RCT, two groups |
| Method | 360° videos as a counselling environment | 360° videos as a counselling environment | 360° videos as a counselling environment | 360° panorama images as a counselling environment |
| Sample size | 23 paediatric patients | 112 paediatric patients | 120 paediatric patients | 92 paediatric patients |
| Country | United Kingdom | Korea | Korea | China |
| Time period | 2016–2017 | 2018 | 2019 | 2019–2020 |
| Scale | Self-developed instrument | Anxiety: OSBD | Anxiety: OSBD | Anxiety: Venham picture test |
| Main results | VR counselling reduced the anxiety of parents. The VR counselling resulted in successful MRI (when awake) in 4 of 5 children for whom routine care would have resulted in an MRI under general anaesthesia. | VR counselling reduced pre-scan anxiety compared to oral counselling (mean difference, 3.0 [95%CI, 1.0–5.0]; $p = 0.004$). VR counselling shortened the process time (mean (SD), 55.1 (21.6) s vs. 75.0 s (42.0)) and reduced the need for repeated procedures compared to oral counselling. | The VR group demonstrated lower OSBD scores, need for parental presence, procedural time, and number of repeated procedures compared to the standard video group. | The VR counselling did not statistically significantly lower anxiety levels when compared to the mock MRI and image booklet. VR counselling reduced anxiety levels among parents. The two tested groups did not significantly differ in terms of motion artefacts. |

*Anxiety*

The State-Trait Anxiety Inventory (STAI) questionnaire[116] consists of two, separate 20-item self-reported scales. The questions are grouped into two subscales that assess state and trait anxiety: state Y1 refers to anxiety at the time of a perceived event and is considered temporary; trait Y2 refers to a personality trait and is considered a personal behavioural attitude towards anxiety. Answers were plotted along a four-point scale, with total scores ranging from 20 to 80; a higher score indicated higher anxiety levels. The following cut-off values were presented in previous research[117–120]: 20–39 mild; 40–59 moderate; and 60–80 severe anxiety. The Cronbach's alpha value for the questionnaire exceeded 0.90.

*CCTA process time*

CCTA process time was calculated from data in the radiological information system, more specifically, arrival at the department, examination start, and examination end. The waiting and examination times were calculated in minutes.

*Statistical analysis*

All of the statistical analyses were performed in IBM SPSS (version 28.0; IBM Corporation, Armonk, NTY). Mean values and standard deviations were used to describe the data for normally distributed variables. The statistical significance of differences between the study groups was assessed using an independent samples t-test, while the differences between time points were assessed using a paired samples t-test. An independent samples t-test was used to compare differences between genders. The threshold for statistical significance was set as $p < 0.05$. Analyses were performed according to the intention-to-treat principle.

**Results**

A total of 361 patients were assessed for eligibility; 54 did not meet the inclusion criteria, mostly due to diagnoses of depression, while 221 declined to participate. A total of 86 patients were randomly assigned to intervention (n = 41) or control (n = 45) groups (Fig. 1). All of the randomised participants completed the study.

*Sociodemographic characteristics of the participants*

The were no statistically significant differences in the sociodemographic characteristics of the two groups at baseline (Table 4).

*Anxiety*

The 360°VCE group demonstrated higher state anxiety (STAI Y1) than the standard care group at the baseline time point ($p = 0.41$). However, the 360°VCE group also showed lower STAI Y1 than the standard care group prior to the CCTA; this difference was statistically significant ($p = 0.015$) (Table 5). When compared to the 360°VCE group, the standard care group showed slightly higher levels of trait anxiety at the baseline ($p = 0.50$) and before CCTA ($p = 0.16$). The change in state anxiety in the 360°VCE group was $-7.34$ (95%CI -9.83 to $-4.86$, $p < 0.001$) from the baseline to the time point right before CCTA; the corresponding change in the standard care group was $-0.98$ (95% CI -1.73 to $-0.22$, $p = 0.012$).

When the STAI scores were expressed according to the suggested STAI cut points, baseline state anxiety was mild in 62,8%, moderate in 32,6%, and severe in 4,7% of participants. For the time point right before CCTA, anxiety was mild in 73,3%, moderate in 25,6%, and severe in 1,2% of the participants (Table 6).

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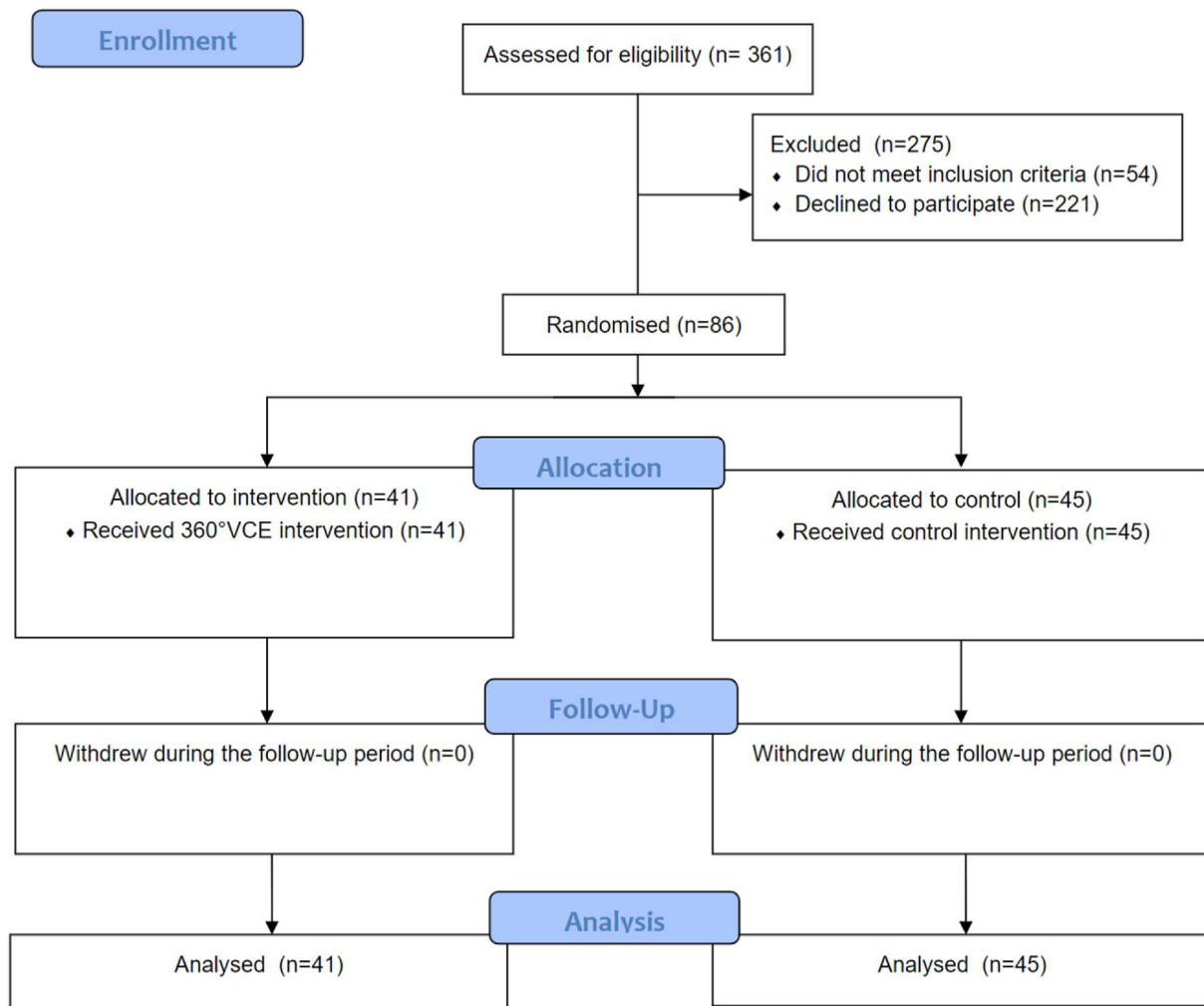
## CONSORT 2010 Flow Diagram



**Figure 1.** PRISMA flowchart of the randomised controlled trial.

Women demonstrated higher state anxiety than men at baseline ($p = 0.020$) and before CCTA ($p = 0.005$) (Multimedia appendix 3 and Fig. 4); both of these gender-specific differences were statistically significant. Similarly, women showed higher trait anxiety than men at baseline ($p = 0.18$) and before CCTA ($p = 0.17$). Age, educational level, marital status, or occupational level were not significantly associated with anxiety, while gender, being away from work, and smoking were associated with higher levels of anxiety at certain time points (Multimedia Appendix 3).

### CCTA process time

Both the 360°VCE and standard care groups showed similar waiting and examination times (Table 5). Of the background factors (Multimedia appendix 3), only age demonstrated a statistically significant association with the secondary outcome variable; more specifically, the patient's age was negatively correlated with the CCTA process time ($p = 0.03$).

### Discussion

We designed a novel 360° virtual counselling environment for CCTA patients[1] which was well accepted by patients and reported to improve patient knowledge about the procedure, increase the patient's senses of security and self-efficacy, and reduce anxiety. In the present study, a methodologically rigorous RCT evaluated anxiety in patients who had either received the VR intervention or the standard care; as such, the presented results provide the most definitive clinical validation of a VR intervention.[121]

This randomised trial provided novel information, as no previous studies on the effect of a 360° environment on anxiety among adult CCTA patients were found. The results demonstrate that access to the 360°VCE reduces CCTA patients' pre-CCTA levels of anxiety, which agreed with previous research on pre-CCTA multimedia education[11] and VR counselling.[51,52,106] However, it should be noted that earlier RCT studies[51,52,107] have focused on paediatric patients and used different scales; this makes any between-study comparisons difficult. Furthermore, these prior
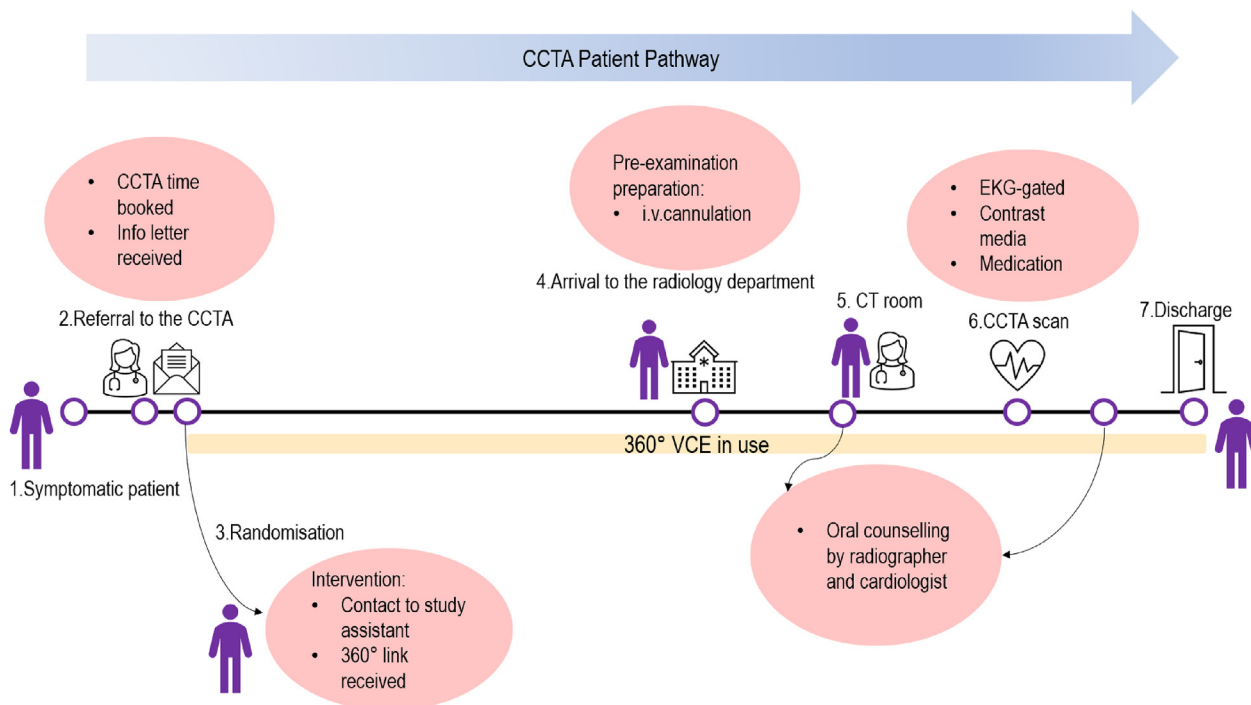
**Figure 2.** CCTA patient pathway of the 360°VCE intervention group.

studies − which applied various instruments − differ in terms of the time points at which medical imaging-related anxiety was measured.[4,5]

The 360°VCE group showed higher baseline STAI-S scores than the control group, which implies that those who are more anxious about a CCTA could benefit from additional 360° VR experiences. A recent review demonstrated that non-pharmacological interventions can significantly decrease adult patient anxiety levels prior to diagnostic imaging procedures.[2]

Our intervention lacked participative features, i.e., it did not involve other forms of interaction such as communication, feedback, or notifications. These aspects have been identified as considerable advantages of eHealth services.[122] Interactive features could be expected to have an even more significant effect on pre-scan anxiety. On the other hand, the increased workload among healthcare personnel after the implementation of an eHealth tool



**Figure 3.** QR-code link to the 360°VCE informational video.

has been described as the most significant barrier to eHealth implementation.[123] Our intervention did not increase the workload of radiographers as patients could independently use the 360°VCE from home.

As was the case in previous research,[5,8,13,75−77,124,125] the female participants of this study showed higher levels of state anxiety than male participants. The fact that most participants in this study were female suggests that females tend to seek solutions to relieve their scan-related anxiety. Even though the groups were statistically similar, the standard care group included five more women than the intervention group. This may partly explain the observed between-group differences in state anxiety. All of the patients in this study were undergoing their first CCTA. Particular attention should be paid to such patients, as previous studies have shown that first-time examinations are associated with higher anxiety levels.[4,5,8,65,72,75,76,78]

The CCTA process times between the groups were similar. In a previous study, 360° VR exerted a positive effect on the time required to perform a chest radiography,[51,52] which usually has a shorter process time than CCTA. In this study, younger participants generally showed longer CCTA examination times, which indicates that this population of patients require a longer preparation time.

This study is the first randomised controlled trial that has estimated the effect of a 360° virtual counselling environment on CCTA-related anxiety. Patients' procedural knowledge was not measured in this study, although previous research has demonstrated that it increases following VR interventions.[63,113] There is still a need for high-quality evidence about the most effective intervention for reducing patient anxiety, as well as the definition of important parameters, such as timing and duration.

The present study implemented most of the elements of a developed framework[121] for best practices in VR-related clinical trials. The most important strength of this study is the randomised design. The reliability and validity of the STAI questionnaire has been validated in many studies and contexts. This further improves the validity of the present study.

**Table 4**
Patient characteristics (N = 86).

| Characteristic | 360°VCE, (n = 41) | Standard care, (n = 45) | p-value |
|---|---|---|---|
| Age in years, median (range) | 56.00 (45–67) | 59.00 (26–73) | 0.16 |
| Gender, n (%) | | | 0.55 |
|   Female | 22 (53.7) | 27 (60) | |
|   Male | 19 (46.3) | 18 (40) | |
| Marital status, n (%) | | | 0.34 |
|   Married/cohabitating | 35 (85.4) | 32 (71.1) | |
|   Separated/divorced | 3 (7.3) | 8 (17.8) | |
|   Single | 3 (7.3) | 4 (8.9) | |
|   Widowed | 0 (0.0) | 1 (2.2) | |
| Education in years, mean (SD) | 15.98 (3.229) | 14.82 (3.645) | 0.12 |
| Employment status, n (%) | | | 0.76 |
|   Full-time | 27 (65.9) | 27 (60,0) | |
|   Part-time | 2 (4.9) | 3 (6,7) | |
|   Sick leave/unemployed | 3 (7.3) | 2 (4,4) | |
|   Retired | 7 (17.1) | 12 (26,7) | |
|   Away from work, other reasons | 2 (4.9) | 1 (2,2) | |
| Occupational level, n (%) | | | 0.16 |
|   Senior employee | 12 (29.3) | 10 (22.2) | |
|   Lower employee | 13 (31.7) | 6 (13.3) | |
|   Vocational education | 12 (28.3) | 23 (51.1) | |
|   Self-employed | 3 (7.3) | 4 (8.9) | |
|   Work without education | 1 (2.4) | 2 (4.4) | |

**Table 5**
Primary outcome scores in the two tested groups.

| Outcome | Baseline, mean (SD) | p-value, group difference baseline | Follow-up, mean (SD) | p-value, follow-up | Change | 95% CI for change | p-value for change |
|---|---|---|---|---|---|---|---|
| STAI Y1 (state anxiety) | | 0.41 | | 0.015 | | | |
|   360°VCE (n = 41) | 37.85 (13.33) | | 30.51 (9.40) | | −7.34 (7.88) | −9.83–4.86 | <0.001 |
|   Standard care (n = 45) | 35.84 (8.54) | | 34.87 (9.02) | | −0.98 (2.51) | −1.73–0.22 | 0.012 |
|   All (n = 86) | 36.80 (11.06) | | 32.79 (9.41) | | −4.01 (6.53) | −5.41–2.61 | <0.001 |
| STAI Y2 (trait anxiety) | | 0.50 | | 0.16 | | | |
|   360°VCE (n = 41) | 34.41 (10.31) | | 33.68 (10.18) | | −0.73 (4.33) | −2.10–0.64 | 0.29 |
|   Standard care (n = 45) | 35.76 (7.60) | | 35.44 (7.28) | | −0.31 (1.92) | −0.89–0.26 | 0.28 |
|   All (n = 86) | 35.12 (8.96) | | 34.60 (8.77) | | −0.51 (3.28) | −1.21–0.19 | 0.15 |
| Waiting time, min | | | | 0.96 | | | |
|   360°VCE | – | | 59.10 (22.22) | | | | |
|   Standard care | – | | 59.38 (26.54) | | | | |
|   All | | | 59.24 (24.43) | | | | |
| Examination time, min | | | | 0.91 | | | |
|   360°VCE | – | | 24.49 (6.87) | | | | |
|   Standard care | – | | 24.31 (7.30) | | | | |
|   All | | | 24.40 (7.06) | | | | |

**Table 6**
Severity of anxiety in groups based on the suggested STAI cut points.

| Outcome | Anxiety | | |
|---|---|---|---|
| | Mild 20–39, n (%) | Moderate 40–59, n (%) | Severe 60–80, n (%) |
| STAI-Y1, baseline; n (%) | | | |
|   360°VCE | 27 (65.9) | 10 (24.4) | 4 (9.8) |
|   Standard care | 27 (60.0) | 18 (40.0) | 0 (0) |
|   All | 54 (62.8) | 28 (32.6) | 4 (4.7) |
| STAI-Y1, follow up; n (%) | | | |
|   360°VCE | 33 (80.5) | 7 (17.1) | 1 (2.4) |
|   Standard care | 30 (66.7) | 15 (33.3) | 0 (0) |
|   All | 63 (73.3) | 22 (25.6) | 1 (1.2) |
| STAI-Y2, baseline; n (%) | | | |
|   360°VCE | 29 (70.7) | 11 (26.8) | 1 (2.4) |
|   Standard care | 28 (62.2) | 17 (37.8) | 0 (0) |
|   All | 57 (66.3) | 28 (32.6) | 1 (1.2) |
| STAI-Y2, follow up; n (%) | | | |
|   360°VCE | 29 (70.7) | 11 (26.8) | 1 (2.4) |
|   Standard care | 30 (66.7) | 15 (33.3) | 0 (0) |
|   All | 59 (68.6) | 26 (30.2) | 1 (1.2) |
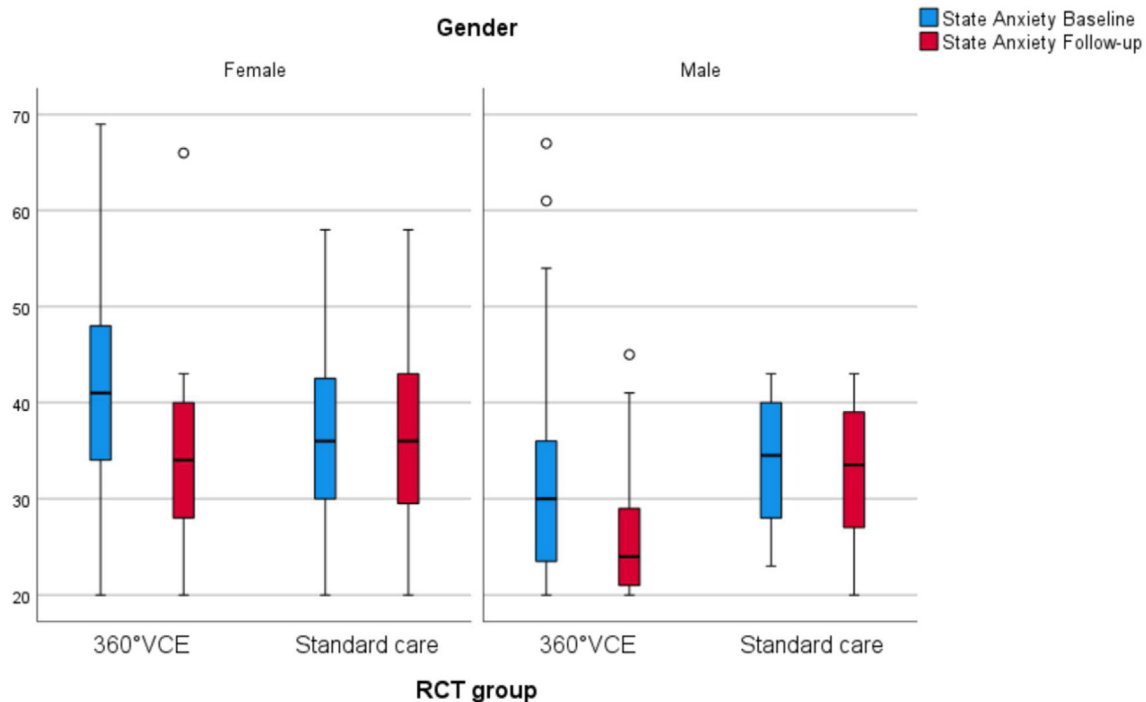
**Figure 4.** State anxiety at baseline and prior to CCTA time points by group and gender.

## Limitations

The main limitation of this study was the small sample size. A larger sample would have increased the validity of the research but would also have prolonged the time needed for recruitment. Additionally, the short duration of the intervention may have affected the effect size. The actual 360°VCE usage time was not measured. The subgroup comparison made between time spent reviewing VCE and resultant level of anxiety could have improved the reliability of the research. As this was a single-centre study, the results may not be generalisable to other contexts. Furthermore, it should be noted that we did not evaluate how previous experiences with medical imaging procedures (such as MRI or previous CT imaging with contrast) affected STAI score; this could have had positive effects on the reliability of the research.

The statistician generated the randomisation programme to ensure that selection bias was reduced as much as possible. However, most of the participants in both groups were female, and the standard care group had a higher percentage of females than the intervention group. It was not possible to blind the participants due to the nature of the intervention.

## Conclusion

This study represents the first assessment of how a 360°VCE affects patients' anxiety and CCTA processing time. The 360°VCE lowered pre-CCTA anxiety. Female participants demonstrated higher levels of pre-CCTA anxiety than male participants. Future research should focus on further understanding the anxiety experienced by both adult CCTA patients and patients enrolled in other medical imaging procedures.

## Conflict of interest statement

The authors declare that there are no conflicts of interest. The study was designed by KP, MV, AH and MK. KP was responsible for enrolling participants, data analysis and drafting the manuscript, while MV, AH, MN and MK made critical and intellectual revisions. TS randomised and instructed the participants. HV planned the randomisation process and advised with the data analysis.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.radi.2022.09.013.

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