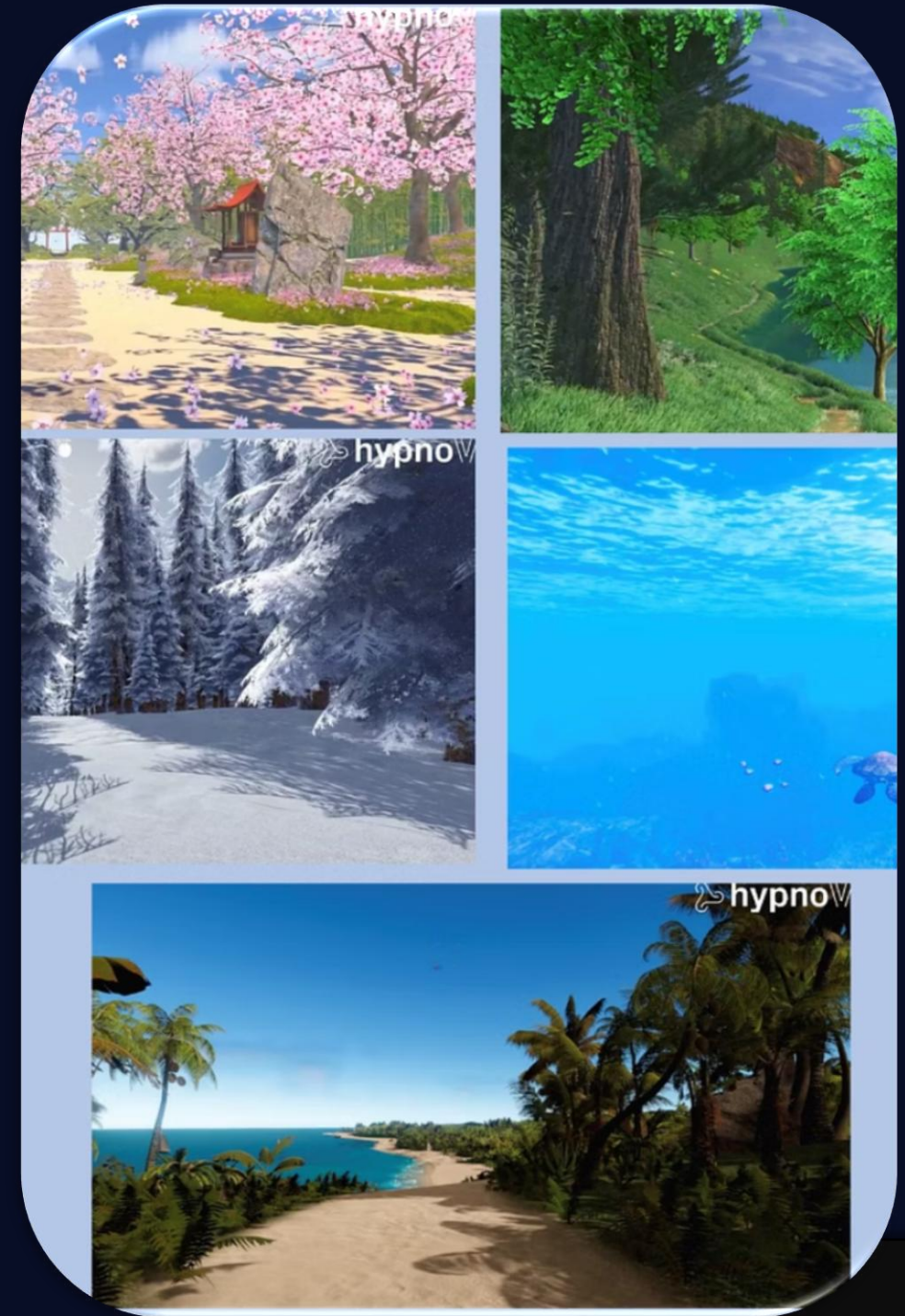# Virtual Reality Augmented ACL Reconstruction
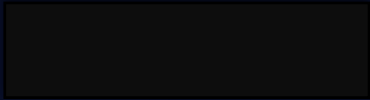# Does it Make a Difference?

Ahmed Mabrouk and Matthieu Ollivier

Disclosures

Ahmed Mabrouk and Matthieu Ollivier have no disclosures.

Clinical Context and Study Objectives

📅 **ACLR as Day-Case Surgery**

ACLR has been performed as outpatient surgery for over two decades, but postoperative pain remains a key contraindication to same-day discharge

🧠 **Anxiety-Pain Connection**

Anxiety can heighten pain perception and severity, potentially delaying discharge in ACLR cases

🥽 **VR Distraction Mechanism**

VR creates immersion in pacifying environments, redirecting attention from pain and anxiety based on limited attentional capacity theory
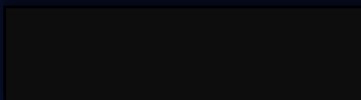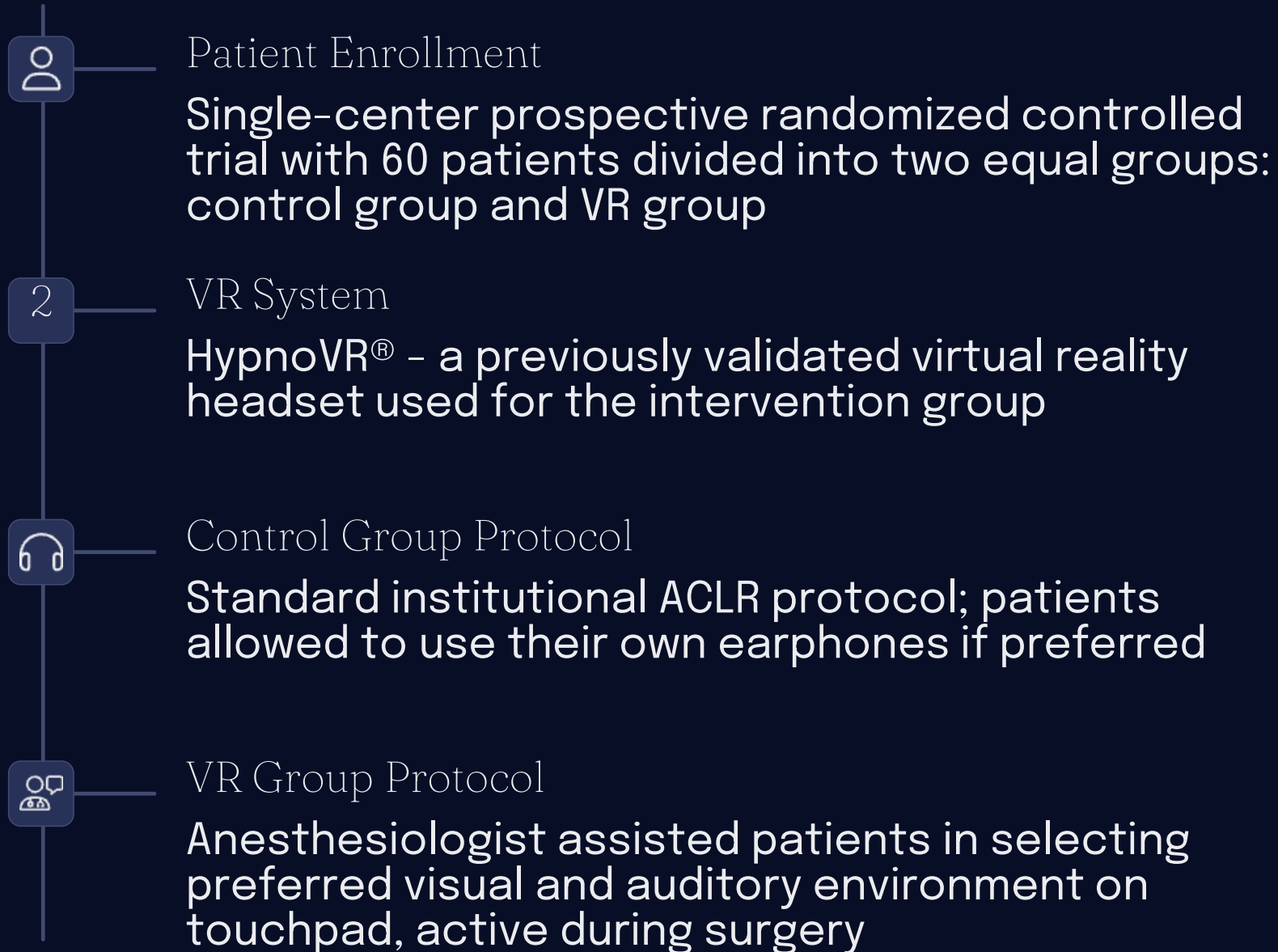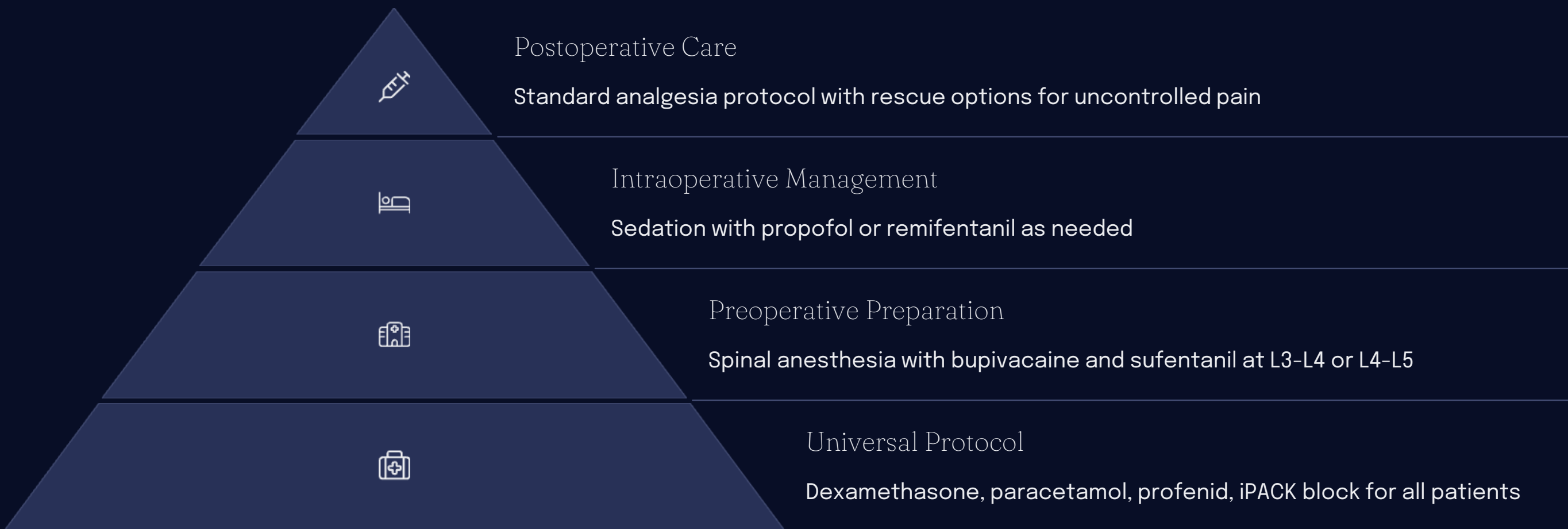
📋 **Study Design**

Primary outcome: postoperative anxiety (STAI Y-1 score); Secondary outcomes: sedation requirements, complications, pain scores, and patient satisfaction

Methodology and VR Implementation

Patient Enrollment

Single-center prospective randomized controlled trial with 60 patients divided into two equal groups: control group and VR group

VR System

HypnoVR® - a previously validated virtual reality headset used for the intervention group

Control Group Protocol

Standard institutional ACLR protocol; patients allowed to use their own earphones if preferred

VR Group Protocol

Anesthesiologist assisted patients in selecting preferred visual and auditory environment on touchpad, active during surgery

Comprehensive Anesthetic Strategy

Postoperative Care

Standard analgesia protocol with rescue options for uncontrolled pain

Intraoperative Management

Sedation with propofol or remifentanil as needed

Preoperative Preparation

Spinal anesthesia with bupivacaine and sufentanil at L3-L4 or L4-L5

Universal Protocol

Dexamethasone, paracetamol, profenid, iPACK block for all patients

Anxiety assessment was conducted at multiple timepoints using the STAI-Y1 form: preoperatively, intraoperatively during skin closure, immediately postoperatively in the recovery room, and before discharge. This comprehensive approach allowed for thorough evaluation of anxiety levels throughout the patient journey.
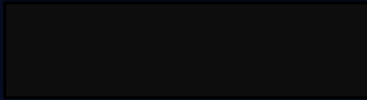
Virtual Reality Environment Options
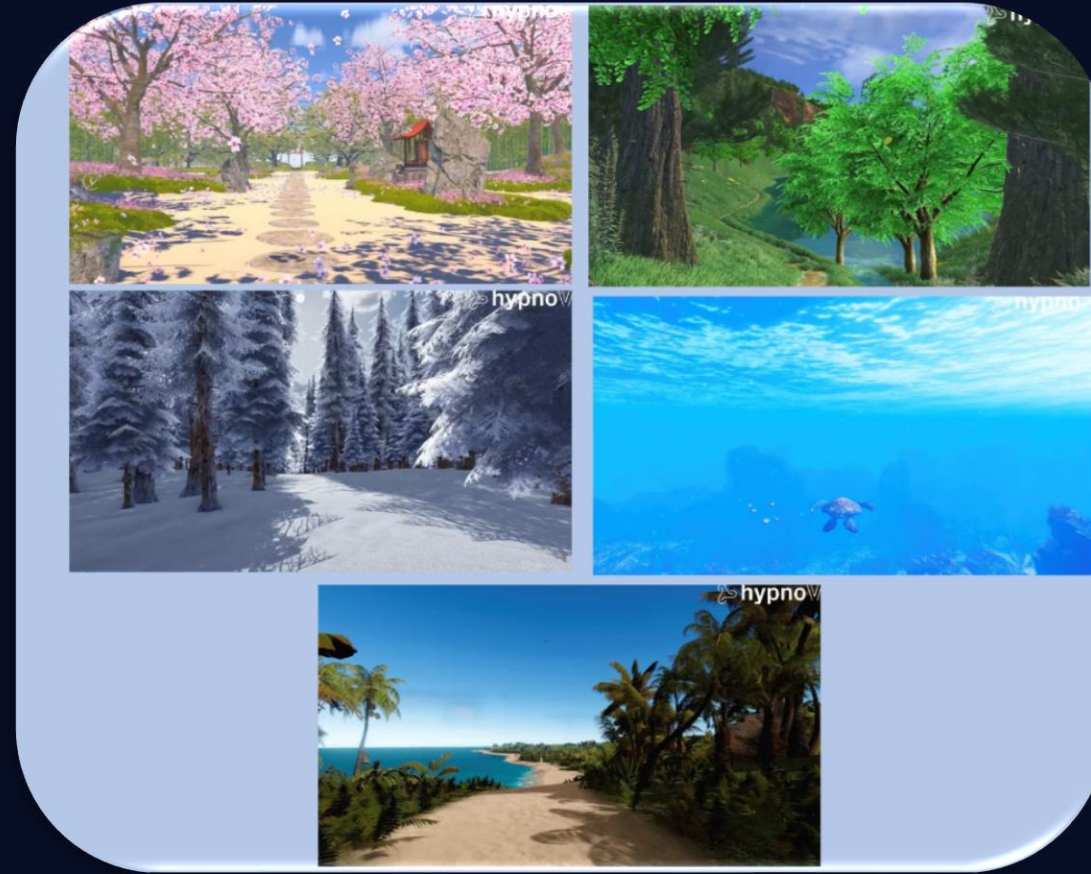
Undergrowth

Natural forest setting with immersive woodland sounds

Tropical Beach

Seaside relaxation with waves and sunny ambiance

Astral Travel

Space-themed environment with cosmic visuals

Snowy Landscape
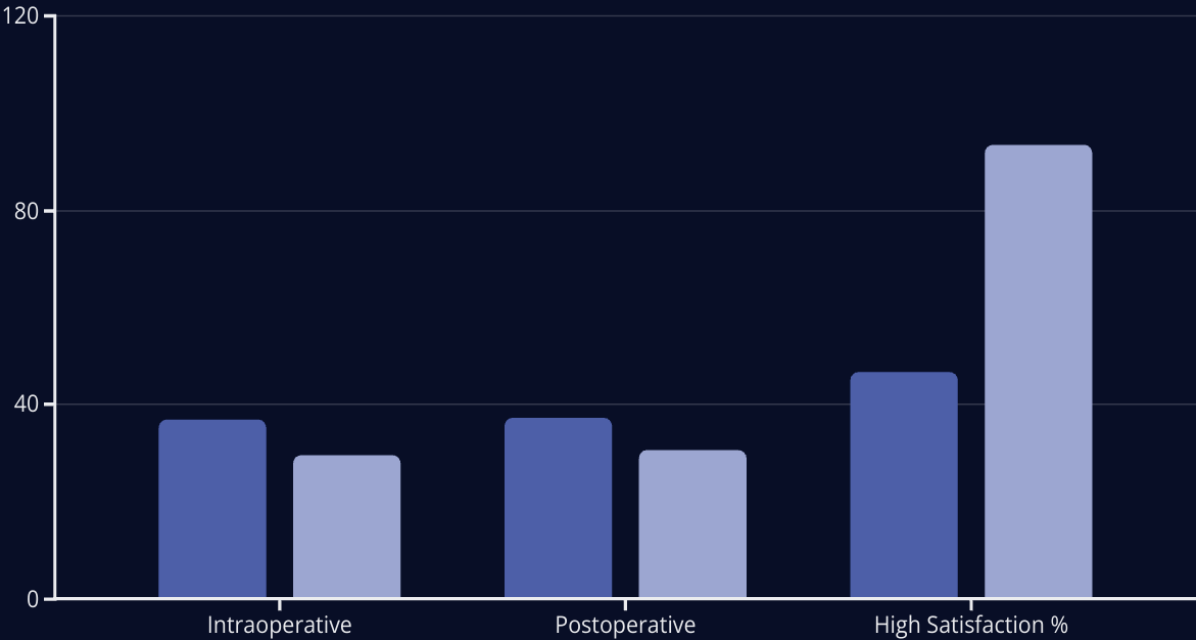
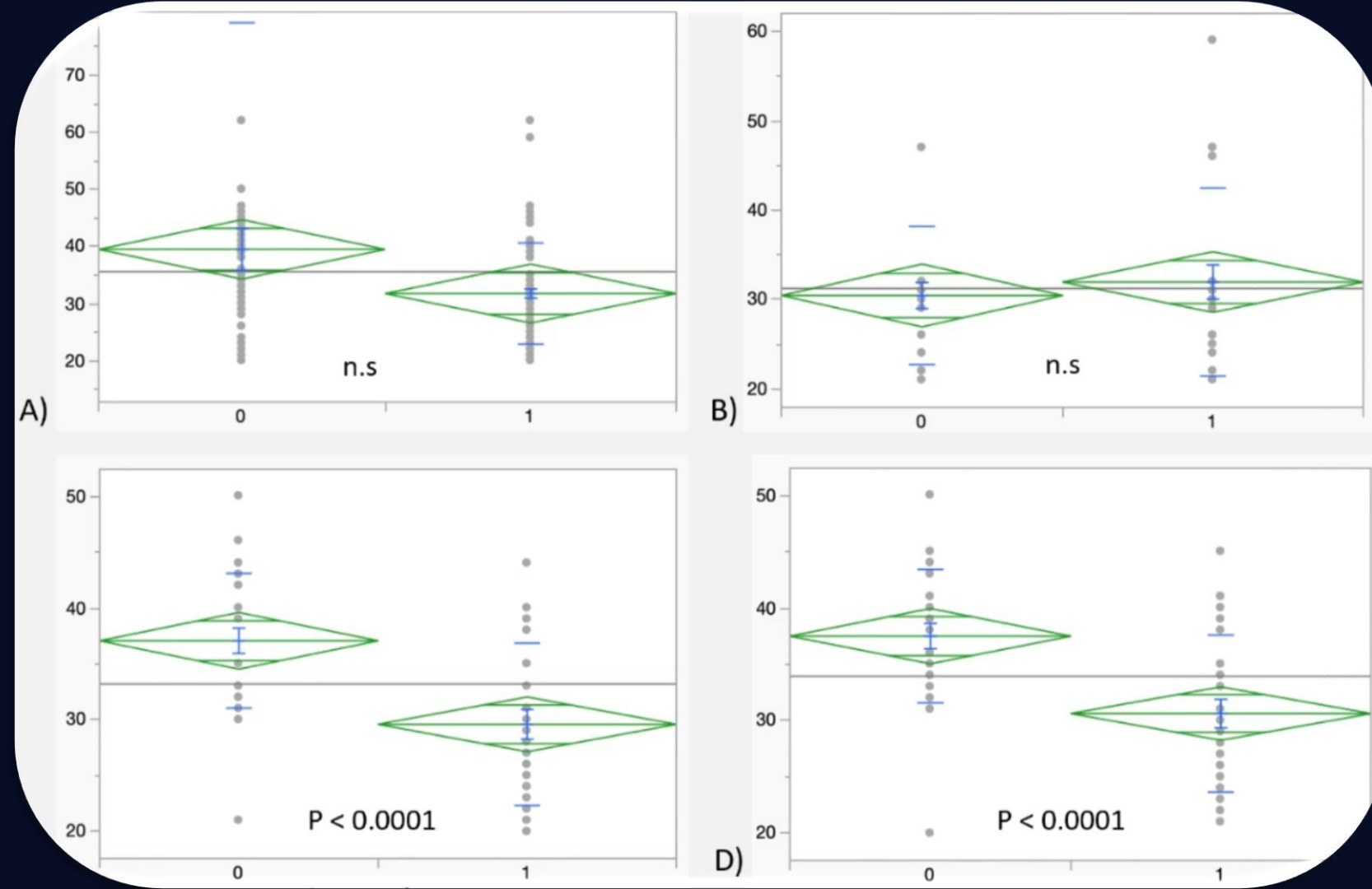Winter wonderland with calming snow effects

Diving

Underwater experience with marine life and ocean sounds

Statistical Results and Outcome Measures

STAI Y-1 Scores	Control group	VR group	P value
STAI Y-1 Preoperative	33.3 ± 7.9 [30.3, 36.3]	34.9 ± 9.7 [31.2, 38.5]	P = 0.8
STAI Y-1 Intraoperative	36.9 ± 5.8 [34.8, 39.1]	29.6 ± 7.3 [26.9, 32,3]	P < 0.0001
STAI Y-1 Postoperative	37.3 ± 5.7 [35.2, 39.5]	30.6 ± 6.9 [28, 32.2]	P < 0.0001

Further Analysis of STAI-Y1 Score Distribution

The box plots clearly illustrate the consistent anxiety reduction pattern across measurement timepoints. While both groups started with similar anxiety profiles, the VR group (1) showed progressively lower STAI-Y1 scores compared to the control group (0) as patients moved through the surgical journey, with the most pronounced differences occurring during and immediately after surgery.

Clinical Implications and Future Directions

|	
✓	**Confirmed Benefits** VR significantly reduces anxiety and improves satisfaction
📋	**Clinical Practice Integration** Implementation protocols for routine ACLR procedures
🔬	**Future Research** Applications for other orthopedic procedures

This study provides compelling evidence that virtual reality-augmented anterior cruciate ligament reconstruction results in significantly fewer intraoperative adverse events, reduced patient anxiety both during and immediately after surgery, and substantially higher overall patient satisfaction.

The integration of VR technology into standard ACLR protocols represents a cost-effective, non-pharmacological approach to improving patient outcomes. Future research should explore applications in other orthopedic procedures and investigate long-term effects on recovery metrics. For additional information, refer to "The Benefits of Intraoperative Virtual Reality Distraction in Anterior Cruciate Ligament Reconstruction (ACLR) Under Spinal Anesthesia" by Mabrouk et al., forthcoming in the Journal of Experimental Orthopaedics, 2025.
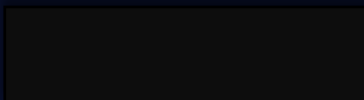
Conclusion: Virtual reality-augmented anterior cruciate ligament reconstruction results in significantly fewer intraoperative adverse events, significantly less intraoperative and less immediate postoperative patient's anxiety, and higher overall patient satisfaction when assessed by the anaesthetic team.
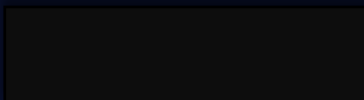
Virtual Reality Augmented ACL Reconstruction
Does it Make a Difference?

Ahmed Mabrouk, Matthieu Ollivier (Marseille , France)

Introduction

For over two decades, ACLR has been performed as a day-case surgery [1, 19, 27]. Nevertheless, among the chief contraindications of same-day discharge is postoperative pain. [11, 37]. Anxiety can increase a patient's perception of the pain and its severity [31]. Hence, anxiety could also lead to a delayed discharge in cases of ACLR.

VR has demonstrated significant capability in patients' distraction from pain and reduction of perioperative anxiety, through immersion in a virtual pacifying environment, with subsequent reduction in the perceived pain and anxiety intensity [22, 29]. This could be explained by the limited attentional capacity theory, where the brain prioritizes which stimuli to attend to due to its limited attentional resources, often focusing on more relevant information and filtering less relevant ones [14].

This study aimed to assess patient anxiety intraoperatively and post-operatively on the same day of ACLR surgery under spinal anaesthesia (SA) with or without VR distraction. The primary outcome was the postoperative patient anxiety level as assessed by State-Trait Anxiety inventory (STAI Y-1) score.

The secondary outcomes were intraoperative sedation requirements, complications (hypotension and oxygen need), postoperative pain and comfort scores on a visual analogue scale (VAS), and patient satisfaction. It was hypothesized that there would be no difference in the primary or secondary outcomes with or without using the VR distraction.

Patients and Methods

A single-centre prospective randomized controlled trial was conducted. During enrolment, the VR principle and protocol were explained to all patients. Then, patients were randomized into 2 groups (each n =30), regardless of the specifics of meniscal injury. Group 1 was a control group, where the standard institutional protocol of ACLR was employed, and group 2 had ACLR with VR headset used. A previously validated virtual reality headset (HypnoVR®) was utilized [13].

On the surgery day, patients in the control group were allowed to use their own earphones should they prefer. Whereas patients in the VR group, had help from the anaesthesiologist to choose their preferred visual and auditory universe on a touchpad, which will be running during the surgery.

Preoperative anaesthetic Strategy:
Premedication was not required for all patients. Spinal anaesthesia was performed using bupivacaine and sufentanil (L3-L4 or L4-L5).

Both groups had dexamethasone 8 mg, paracetamol 1 g/6 h, profenid 100 mg/8 h IV. Droleptan was administered based on the Apfel score [3].Additionally, all patients had an iPACK block (infiltration between the popliteal Artery and Capsule of Knee).
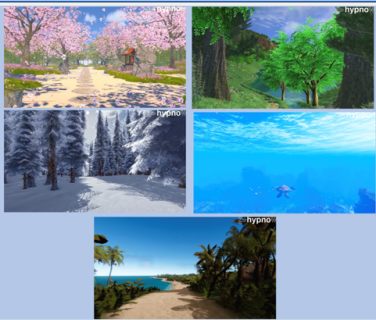

Figure 1: Demonstration of the screen view for the five VR universes proposed for the patient on the touchpad before the surgery.

A proposal of five universes was made: undergrowth, astral travel, snowy landscape, diving, and tropical beach **Figure 1** Additionally, visual support with either a male or a female voice was available to play.

Intraoperative anaesthetic Strategy:

Sedative medications were used if required for any patient in both groups. Propofol or remifentanil in TIVAC was used. Whenever sedation was not sufficient, a conversion to general anaesthesia was performed.

Postoperative anaesthetic Strategy:

After surgery completion, all patients were recovered in the recovery room. A standard analgesia protocol was prescribed: paracetamol 1 g/6 h, profenid 100 mg/12 h (depending on renal function).

In scenarios where the pain was uncontrolled (EVA > 3), rescue analgesia was used. A morphine titration was performed at 0.1 mg/kg (max 4 mg), then repeated injections every 5 min of 0.0025 mg/kg until sufficient analgesia was achieved. When the patient experienced nausea or vomiting, ondansetron 4 mg was administered.

The patient's anxiety was assessed in several settings: preoperatively, intraoperatively (during skin closure), immediately postoperatively (In the recovery room), and before discharge, using the form STAI-Y1.

Results

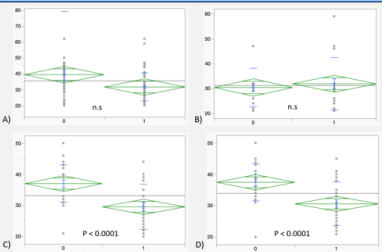| Variable	Control Group	VR Group
Age	30.6 ± 12.9	28.8 ± 9.5
	[25.7, 35.6]	[25.3, 32.4]
Gender		
Male	21 (70%)	19 (63.3%)
Female	9 (30 %)	11 (36.3 %)
BMI (kg/m²)	19.3 ± 1.4	19.1 ± 0.8
	[18.7, 19.8]	[18.8, 19.4]

Figure 2: Plots demonstrating the difference in the STAI-Y1 scores between the control group **(0)** and the VR group **(1)**: **A)** Preoperatively in the department **B)** Preoperatively in the anaesthetic room **C)** Intraoperatively during skin closure **D)** postoperatively in the anaesthetic room.

STAI Y-1 Scores	Control group	VR group	P value
STAI Y-1 Preoperative	33.3 ± 7.9	34.9 ± 9.7	P = 0.8
	[30.3, 36.3]	[31.2, 38.5]	
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	[35.2, 39.5]	[28, 32.2]	

Discussion

In the presented study, there was a significant reduction in intraoperative patient anxiety when a VR headset was used compared to the control group.

This was demonstrated by low intraoperative STAI-Y1 scores of 29.6 ± 7.3 in the VR group versus 36.9 ± 5.8 in the control group. Additionally, an immediate postoperative STAI-Y1 scores were significantly lower in the VR group versus the control group, 30.6 ± 6.9 versus 37.3 ± 5.7, respectively (both p < 0.0001).

Moreover, anaesthetic evaluation of patient satisfaction demonstrated a significantly higher percentage of patients reporting high satisfaction in the VR group compared to the control group 93.3% vs 46.7%, respectively (p < 0.0001).

Conclusion

Virtual reality-augmented anterior cruciate ligament reconstruction results in significantly fewer intraoperative adverse events, significantly less intraoperative and less immediate postoperative patient's anxiety, and higher overall patient satisfaction when assessed by the anaesthetic team.

References

The Benefits of Intraoperative Virtual Reality Distraction in Anterior Cruciate Ligament Reconstruction (ACLR) Under Spinal Anesthesia. **Mabrouk A**, Peuchot H, Jacquet C, Onishi S, Ollivier M. Journal of Experimental Orthopaedics. 2025.

References: *The Benefits of Intraoperative Virtual Reality Distraction in Anterior Cruciate Ligament Reconstruction (ACLR) Under Spinal Anesthesia. Mabrouk A, Peuchot H, Jacquet C, Onishi S, Ollivier M. Journal of Experimental Orthopaedics. 2025.*