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Comparison of Robot-Assisted and Extended Reality-Assisted Vertebral Augmentation: Systematic Review and Comparative Analysis

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ADMINISTRATIVE INFORMATION

Support - N/A.

Review Stage at time of this submission - Preliminary searches.

Conflicts of interest - None declared.

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Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 15 December 2024 and was last updated on 15 December 2024.

INTRODUCTION

Review question / Objective How does RA (robot-assisted) vertebral augmentation compare to XR (extended reality)-assisted vertebral augmentation in terms of operative time, fluoroscopy frequency, and postoperative pain and disability scores?

Condition being studied This study examines the vertebral augmentation procedure to treat vertebral compression fractures.

METHODS

Participant or population The types of participants in this study include patients that have undergone vertebral augmentation with fluoroscopy-assisted, robot-assisted, or extended reality-assisted kyphoplasty and vertebroplasty procedures.

Intervention The interventions evaluated in this review are robot-assisted (RA) and extended reality (XR) modalities in vertebral augmentation procedures, including kyphoplasty and vertebroplasty. RA vertebral augmentation uses robotic systems to enhance depth perception, range of motion, and intraoperative navigation, aiming to reduce fluoroscopy frequency, bone cement leakage, and procedural invasiveness. Meanwhile, XR vertebral augmentation uses technologies such as augmented reality, mixed reality, or virtual reality to increase surgical accuracy and intraoperative decision-making.

Comparator The comparative intervention applied to the target population in this review is fluoroscopy-assisted (FA) vertebral augmentation, which serves as the conventional standard for procedures like kyphoplasty and vertebroplasty. This technique relies on real-time imaging using fluoroscopy to guide the placement of instruments and bone cement during vertebral augmentation. It provides a baseline against which the efficacy and safety of robot-assisted (RA) and extended reality (XR) modalities will be evaluated.

Study designs to be included Most types of studies, which included randomized controlled trials, cohort studies, case-control studies, and case reports.

Eligibility criteria Studies that compared RA or XR modalities with FA kyphoplasty and vertebroplasty procedures were considered eligible and included in our review. The inclusion criteria for this systematic review included (1) Studies that compared RA or XR with freehand fluoroscopy for kyphoplasty and vertebroplasty procedures, (2) Articles published in peer-reviewed journals, (3) Studies that were written in English, and (4) Most types of studies, which included randomized controlled trials, cohort studies, case-control studies, and case reports. Exclusion criteria included (1) Studies that do not include RA or XR in vertebral augmentation (2) Non-peer-reviewed articles, editorials, commentaries, review articles, and conference abstracts (3) Studies that did not include data on outcomes.

Information sources The intended information sources for this systematic review include multiple comprehensive and reputable electronic databases and other methods to ensure a thorough search for relevant studies. The electronic databases searched include PubMed, SCOPUS, EMBASE, and the Cochrane Library. These allow for a wide range of peer-reviewed articles, clinical trials, and systematic reviews relevant to vertebral augmentation procedures.

Main outcome(s) The main outcomes include operative time, fluoroscopy frequency, immediate VAS post-op, extended VAS follow-up, immediate ODI post-op, and extended ODI follow-up.

Quality assessment / Risk of bias analysis The quality assessment of primary studies included in this review was not conducted. Risk of bias or sensitivity analyses were not performed for the included studies. This was a limitation of the review, as further discussed in the paper.

Strategy of data synthesis We systematically performed a literature search on October 26, 2024, through PubMed, SCOPUS, EMBASE, and Cochrane was conducted using a combination of the following keywords: “Robot,” “Robot-assisted,” “Mixed-Reality,” and “Augmented-Reality” with “Vertebral Augmentation,” “Kyphoplasty,” “Vertebroplasty,” and “Spinal Augmentation.” Certain studies require a subgroup analysis because they included more groups. Some of the subgroup analyses include experience with technology, assistive technology, registration time, and varying segmentation levels.

Subgroup analysis Subgroup analysis was not performed for this study.

Sensitivity analysis Sensitivity analysis was not performed for this study.

Language restriction English.

Country(ies) involved United States of America.

Keywords Vertebral augmentation; Robot-assisted; Extended Reality; Pain; Kyphoplasty; Vertebroplasty.

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