Abstract

The integration of virtual reality (VR) in preoperative planning offers a transformative approach to complex surgeries. This study presents the development and application of a VR surgical planning system designed to enhance the accuracy and efficiency of preoperative planning through immersive, three-dimensional (3D) visualizations of patient-specific anatomy derived from 2D image data. Our system facilitates real-time, interactive collaboration among multidisciplinary teams, enabling a comprehensive evaluation of surgical strategies. The process involves semi-automatic segmentation and manual refinement to generate high-fidelity 3D models, optimized using mesh processing techniques. Initial validation through a pilot study with clinical participants demonstrated the system's functional accuracy and potential to improve surgical outcomes. This research highlights the significant advancements in surgical planning technology and outlines future directions for further enhancement and broader application.

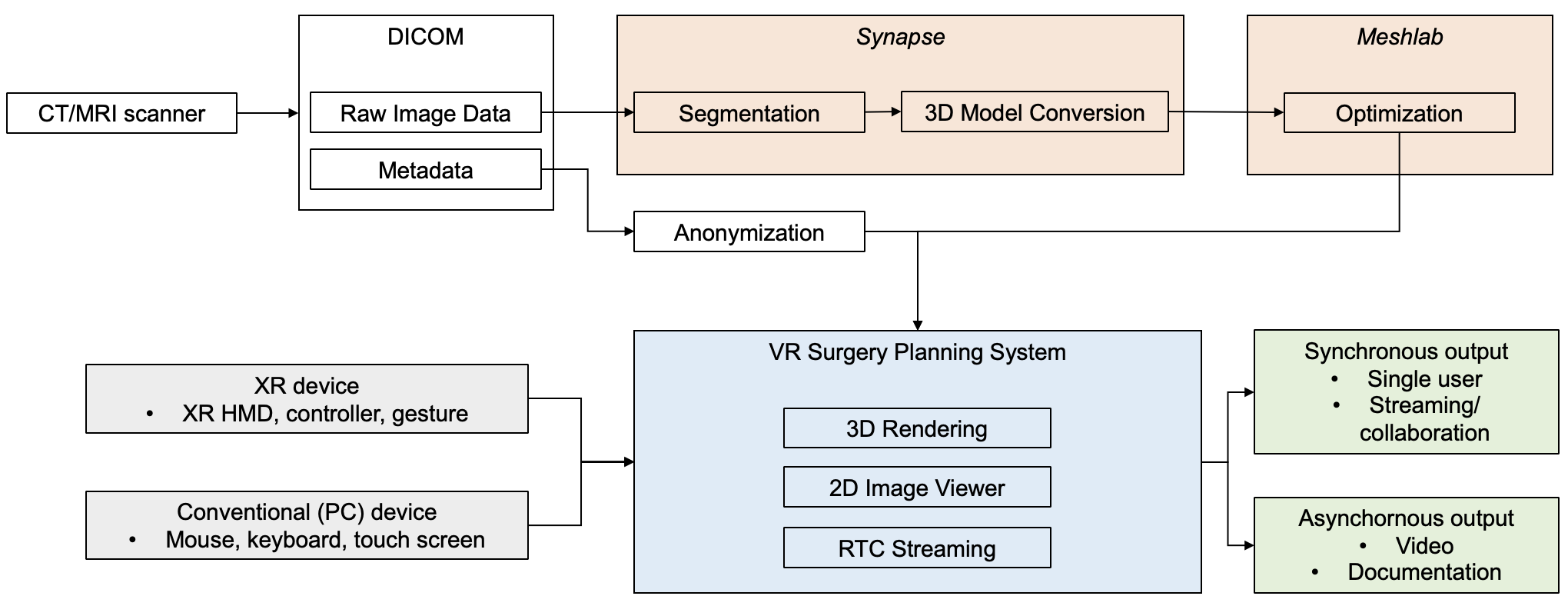
1. Introduction

Planning for complex surgical procedures presents numerous challenges and difficulties, primarily due to the intricate and variable nature of human anatomy. The success of such interventions heavily relies on the surgeon's ability to anticipate and navigate these complexities, underscoring the importance of integration of advanced imaging and planning tools that can provide a detailed and accurate representation of the patient-specific anatomy \cite{RN30}.

Virtual reality (VR) offers a promising solution to the challenges inherent in complex surgery planning \cite{RN32, RN31, RN2, RN24}. By providing immersive, three-dimensional (3D) visualizations of patient-specific anatomy, VR enables surgeons to interact with and manipulate anatomical models in a immersive nature. This interactive capability allows for a more thorough visuospatial conversion from two-dimensional (2D) images, optimizing strategic planning. Supported by advancements in computing power and hardware \cite{RN33}, applications of VR in preoperative planning have demonstrated clinical benefits for both patients and physicians, including changes in preoperative planning \cite{RN17, RN13, RN37, RN10, RN44, RN29}, improvements in surgical decision-making \cite{RN5}, and reductions in operative times \cite{RN36, RN28} across multiple surgical subspecialties \cite{RN38, RN2}.

Integration with communication technologies can further enhance the convenience and accessibility of preoperative planning. The flexibility provided by enabling real-time interaction between multidisciplinary teams ensures that critical insights and decisions can be made without the need for all team members to be physically present in the same location \cite{RN26, RN6}. The combination of virtual reality with network communication can facilitate mutual understanding and collaboration among surgical team members, which is crucial for both patient outcomes and physician efficiency \cite{RN62, RN25}.

In this work, we develop a VR surgical planning system, ColabSurgVR. This system allows multiple users to examine the patient organ model reconstructed from computed tomography (CT) dataset and collaborate on forming a preoperative plan in real time. Also we describe a protocol to process patient-specific image datas into 3D models for immersive interaction in virtual environment. To test the use case and performance, we have conducted a pilot user study involving 10 physicians to examine real world patient data present the preliminary qualitative result.

1. System Design and Implementation

Our proposed pipeline takes the imaging data from CT and generates a 3D model for viewing in virtual reality. It involves processing steps to segment the content of the images and reconstrct the anatomy for the patient. The resultant 3D models will be further modified and then imported into our VR surgical planning system supporting immersive visulization and intuitive interaction. The user can assess the system either by extended reality or conventional devices. See Fig ???. for schematic representation of our workflow and system architecture.

* 1. Medical Image Acquisition

Volumetric data acquired from computer tomography (CT) scanners was output in the Digital Imaging and Communication (DICOM) format. The slice thickness was set to 1 mm for acquisition protocol, and all images were reconstructed into 3 mm slices for subsequent interpretation and analysis.

* 1. Segmentation and Virtual Reality Object Generation

The DICOM images were anonymized and then imported into a commercially available medical imaging workstation, Synapse 3D (Fujifilm, Tokyo, Japan), for 3D visualization, segmentation, and 3D model generation. Skin, bones, vascular structures, bronchi, bronchopulmonary segments, and tumors (if present) were segmented from the CT datasets semiautomatically using built-in extraction functions in Synapse 3D Viewer and Lung Analysis Resection applications. Additional segmentation of small branches and border modification were performed manually by assigning or deleting pixels in the image dataset to the corresponding desired anatomic structures. Isolation of submodels (e.g., isolating a rib from the bone models) was also conducted by manually dividing the segmented data. During manual refinement, the CT image data with adjustable window settings and a 3D volumetric rendering of the segmented region were both available to the operator for optimal evaluation and stereoscopic visualization. After segmentation, texture mapping was applied to define surface texture and color information of the segmented data. The resulting data were then exported into a standard tessellation language (STL) file format.

* 1. Model Optimization

To optimize the mesh representation of the 3D models, an open-source 3D mesh processing software, MeshLab (version 2023.12), was utilized \cite{RN19}. The STL files were imported into MeshLab and first underwent a series of cleaning operations, including the removal of duplicated vertices, unreferenced vertices, and zero-area faces to enhance the mesh integrity. Then, quadric edge collapse decimation targeting a 50% reduction in face count was applied to reduce the polygon count while preserving essential geometric features \cite{RN20}. Laplacian smoothing was applied to ensure balanced surface smoothness. Normals were recomputed to correct any lighting and shading inconsistencies using weighted normal calculation. Finally, isolated mesh components were removed, with the minimum component size set to 10% of the overall model diameter. The optimized meshes were then exported in OBJ format for integration into our VR surgery planning system.

* 1. VR Environment Development

For the presentation and interaction with the 3D models, we developed our software using the Unity 3D engine (Unity Technologies, San Francisco, CA, version 2020.3) and integrated it with the Meta XR All-in-One SDK (version 60). We employed the Universal Rendering Pipeline (URP) from Unity, which facilitated optimized graphics performance across various platforms, including mobile devices, PCs, and head-mounted displays (HMDs) utilized in our study.

The software was deployed on an Omen 16 laptop (HP Inc., Palo Alto, California) featuring an Intel® Core™ i7-12700H CPU at 2.30 GHz, 16 GB of RAM, and an NVIDIA® GeForce™ RTX 3070 graphics card. For an immersive virtual reality experience, we used the Meta Quest Pro and Meta Quest 3 HMDs (Meta, Menlo Park, California), along with their corresponding controllers. The Meta Quest Pro offers a resolution of 1800 x 1920 pixels per eye, a refresh rate of 72/90 Hz, and a field of view of 106 degrees. The Meta Quest 3 enhances these specifications with a resolution of 2064 x 2208 pixels per eye, a refresh rate of up to 120 Hz, and a field of view of 110 degrees. These devices provided stereoscopic visualization and interaction, dynamically adjusting the medical image data according to the user's movements and positional changes. During software operation, the HMD was connected to the computer via the built-in link functionality of the Meta Quest models.

* 1. User Interaction and Interfaces

As handheld controllers provide a more intuitive approach for interaction within a 3D virtual reality setting compared to conventional 2D controls, we implemented several interaction functions using the Meta Quest Touch Pro Controllers and Meta Quest 3 Touch Plus Controllers. Additionally, we developed an intuitive Graphical User Interface (GUI) to serve as a menu for segmented regions of the 3D models, anonymized patient profiles, and quick access to certain functions (Fig ???). The core interactions implemented in our system included:

* Continuous translation in all six degrees of freedom (6DoF)
* Continuous rotation in all three degrees of rotational freedom (3DoF)
* Selective visibility and transparency of individual segmented regions of the model
* Measurements of omnidirectional linear distance on the volume by placing start and end points
* Marking and drawing on the volume freely

A concurrent 2D slice image viewer was developed for comparison and correlation between 3D models and conventional medical images, including CT and MRI. A virtual cutting plane on the 3D models represented the corresponding level of the slice (Fig ???) and translated accordingly when the user scrolled through the images.

* 1. Synchronous Sharing

To enable real-time collaboration, education, and general communication, we develop a streaming feature that allows users without HMDs to join the preoperative planning system using conventional input devices and built-in browsers. Leveraging web real-time communication (WebRTC), we establish an extended reality (XR) cloud streaming service and a server. When the main user interacts with the system, updates are sent to the server, which then multicasts these updates to other clients \cite{RN12}. Additionally, audio from the main user can be broadcasted to remote audiences.

1. Methods

We design a pilot study with 10 participants, including 3 attending surgeons and 7 residents. The purpose of the study is to perform an initial validation of the system and the recorded data rather than to characterize the performance of the participants. Written informed consent is obtained from all patients included for VR collaborative surgical planning with the system described above. After an introduction and familiarization session with the system, all participating physicians evaluate the patient-specific models as the main user, with no time limitations. Each participant also joins an additional session using smartphones to participate online. This study is approved by Research Ethics Committee of our institutional review board under 202305019RINC (approval date 2023/10/23). Informed consent is obtained from all participants, including physicians and patients.

1. Results

The presented pipeline requires approximately an hour from importing raw data to presentation of 3D models in the VR system. This time estimate comes from running the program on the aforementioned computing resources and device.

The segmentation and visual fidelity of the end product was verified in both conventional 2D displays and HMDs, which are rated functionally accurate by all partcipants. The results for one patient are shown in Figure ??? and video ???.

1. Discussion

Surgical interventions for complex pathologies are highly intricate, requiring precise planning to optimize outcomes while preserving critical structures. These challenges necessitate advanced preoperative planning solutions that enable detailed visualization and interaction with patient-specific anatomy. Our virtual reality collaborative preoperative planning system addresses these needs by providing a workflow for reconstructing patient-specific 3D anatomic models from 2D image data. This VR system facilitates collaborative interaction and annotation of these virtual models in an immersive environment.

The quality of the input data directly affects the fidelity of the 3D reconstructions in the virtual environment \cite{RN7, RN45}. To avoid loss of detail in the 3D models, acquisition and processing parameters of CT/MRI data need to be calibrated and standardized. Slice thickness of CT has been shown to be one of the primary factors affecting 3D model resolution and quality, with multiple studies proposing a maximum threshold of 1.25 mm \cite{RN7, RN47}. Consequently, we adopted a similar setting for input quality selection in our study.

The segmentation process is one of the most time- and resource-critical steps in generating anatomically accurate models. Manual segmentation by trained physicians or technicians has been extensively adopted in previous studies, achieving acceptable accuracy \cite{RN17, RN48, RN49}. However, the workload of manual tracing limits its efficiency, cost-effectiveness, and reproducibility. Semi-automatic or automatic segmentation aims to replace manual labor with computational processes. Methodologies including thresholding, neural networks, and other machine learning algorithms have been reported for segmenting normal tissues \cite{RN50} or pathologies \cite{RN53, RN52, RN54, RN55} across different regions. Semi-automatic segmentation alleviates the manual workload by efficiently producing segments of different organs while preserving the flexibility of manual editing for rare anatomical variations or complex pathologies. As demonstrated in our study, integrating semi-automatic segmentation into the generation of 3D-VR models has proven feasible and clinically useful for preoperative planning \cite{RN10, RN23}. A fully automatic process to segment multiple structures within a region of interest could potentially further improve efficiency and facilitate streamlining the process into an executable pipeline \cite{RN51, RN57, RN56}. However, there is still limited evidence on the feasibility of incorporating such a strategy into clinical planning \cite{RN9}.

Mesh optimization is essential in virtual reality (VR) to ensure smooth and immersive user experiences \cite{RN58}. Optimization techniques like polygon reduction and smoothing are crucial for managing the high computational demands of VR applications \cite{RN58, RN59}. Several open-source computer-aided design software packages are available and validated for generating and editing 3D medical models \cite{RN60, RN5}. In our study, we adopted MeshLab, which provides a wide range of advanced tools and functionalities and is supported by some of the largest online communities at present times \cite{RN61}.

Implementing multi-user collaboration in a virtual environment provides an innovative way for communication in medical settings. The benefits extend beyond preoperative planning into surgical simulation, personnel training, and education purposes \cite{RN64, RN26, RN65}. To maximize the advantages of collaborative features while addressing the cost of current HMDs, our system allows users to join via conventional devices with network connection and browsers. This approach not only ensures convenience and accessibility but also offers a comparable user experience for those using non-HMD devices, facilitating spectating and interaction without compromising the overall quality \cite{RN63}.

1. Conclusion and Future Work

We present the system architecture and technical setup of ColabSurgVR, a virtual reality collaborative system for preoperative planning. Our workflow involves creating detailed, patient-specific anatomical models from 2D image data and presenting them in an immersive, three-dimensional visualization platform. This interactive environment enhances the accuracy of surgical planning and enables real-time collaboration among multidisciplinary teams. Initial validation through a prospective pilot study with clinical participants demonstrated the system's accuracy and potential clinical benefits.

Future research will focus on enhancing the capabilities and usability of our VR system. One area of focus is optimizing computational processes to achieve rapid turnaround times suitable for emergent surgeries. Additionally, expanding and validating the VR system's application in clinical practice through comparative trials with more participants and patients will help assess its clinical impact on both surgeon-specific and patient outcomes. The proposed system could also be beneficial for a wide range of clinical applications beyond surgical planning, including physician training, student teaching, case collection, and patient communication.

@article{RN17,

author = {Abjigitova, D. and Sadeghi, A. H. and Peek, J. J. and Bekkers, J. A. and Bogers, Ajjc and Mahtab, E. A. F.},

title = {Virtual Reality in the Preoperative Planning of Adult Aortic Surgery: A Feasibility Study},

journal = {J Cardiovasc Dev Dis},

volume = {9},

number = {2},

note = {2308-3425

Abjigitova, Djamila

Sadeghi, Amir H

Peek, Jette J

Orcid: 0000-0002-8412-2851

Bekkers, Jos A

Bogers, Ad J J C

Mahtab, Edris A F

Orcid: 0000-0003-2647-5509

Journal Article

Switzerland

2022/02/25

J Cardiovasc Dev Dis. 2022 Jan 18;9(2):31. doi: 10.3390/jcdd9020031.},

abstract = {Background: Complex aortic anatomy needs careful preoperative planning in which a patient-tailored approach with novel immersive techniques could serve as a valuable addition to current preoperative imaging. This pilot study aimed to investigate the technical feasibility of virtual reality (VR) as an additional imaging tool for preoperative planning in ascending aortic surgery. Methods: Ten cardiothoracic surgeons were presented with six patients who had each undergone a recent repair of the ascending aorta. Two-dimensional computed tomography images of each patient were assessed prior to the VR session. After three-dimensional (3D) VR rendering and 3D segmentation of the ascending aorta and aortic arch, the reconstructions were analyzed by each surgeon in VR via a head-mounted display. Each cardiothoracic surgeon completed a questionnaire after each planning procedure. The results of their assessments were compared to the performed operations. The primary endpoint of the present study was a change of surgical approach from open to clamped distal anastomosis, and vice versa. Results: Compared with conventional imaging, 80% of surgeons found that VR prepared them better for surgery. In 33% of cases (two out of six), the preoperative decision was adjusted due to the 3D VR-based evaluation of the anatomy. Surgeons rated CardioVR usefulness, user-friendliness, and satisfaction with median scores of 3.8 (IQR: 3.5-4.1), 4.2 (IQR: 3.8-4.6,) and 4.1 (IQR: 3.8-4.7) on a five-point Likert scale, respectively. Conclusions: Three-dimensional VR imaging was associated with improved anatomical understanding among surgeons and could be helpful in the future preoperative planning of ascending aortic surgery.},

keywords = {aortic arch surgery

ascending aorta

surgical planning

virtual reality},

ISSN = {2308-3425},

DOI = {10.3390/jcdd9020031},

year = {2022},

type = {Journal Article}

}

@article{RN32,

author = {Arjomandi Rad, A. and Vardanyan, R. and Thavarajasingam, S. G. and Zubarevich, A. and Van den Eynde, J. and Sá, Mpbo and Zhigalov, K. and Sardiari Nia, P. and Ruhparwar, A. and Weymann, A.},

title = {Extended, virtual and augmented reality in thoracic surgery: a systematic review},

journal = {Interact Cardiovasc Thorac Surg},

volume = {34},

number = {2},

pages = {201-211},

note = {1569-9285

Arjomandi Rad, Arian

Orcid: 0000-0002-4931-4049

Vardanyan, Robert

Orcid: 0000-0002-8111-2084

Thavarajasingam, Santhosh G

Zubarevich, Alina

Orcid: 0000-0002-2444-5747

Van den Eynde, Jef

Orcid: 0000-0002-5606-376x

Sá, Michel Pompeu B O

Zhigalov, Konstantin

Orcid: 0000-0002-6440-3736

Sardiari Nia, Peyman

Ruhparwar, Arjang

Orcid: 0000-0003-2725-9912

Weymann, Alexander

Orcid: 0000-0003-2966-6159

Journal Article

Systematic Review

England

2021/09/21

Interact Cardiovasc Thorac Surg. 2022 Jan 18;34(2):201-211. doi: 10.1093/icvts/ivab241.},

abstract = {OBJECTIVES: Extended reality (XR), encompassing both virtual reality (VR) and augmented reality, allows the user to interact with a computer-generated environment based on reality. In essence, the immersive nature of VR and augmented reality technology has been warmly welcomed in all aspects of medicine, gradually becoming increasingly feasible to incorporate into everyday practice. In recent years, XR has become increasingly adopted in thoracic surgery, although the extent of its applications is unclear. Here, we aim to review the current applications of XR in thoracic surgery. METHODS: A systematic database search was conducted of original articles that explored the use of VR and/or augmented reality in thoracic surgery in EMBASE, MEDLINE, Cochrane database and Google Scholar, from inception to December 2020. RESULTS: Our search yielded 1494 citations, of which 21 studies published from 2007 to 2019 were included in this review. Three main areas were identified: (i) the application of XR in thoracic surgery training; (ii) preoperative planning of thoracic procedures; and (iii) intraoperative assistance. Overall, XR could produce progression along the learning curve, enabling trainees to reach acceptable standards before performing in the operating theatre. Preoperatively, through the generation of 3D-renderings of the thoracic cavity and lung anatomy, VR increases procedural accuracy and surgical confidence through familiarization of the patient's anatomy. XR-assisted surgery may have therapeutic use particularly for complex cases, where conventional methods would yield inadequate outcomes due to inferior accuracy. CONCLUSION: XR represents a salient step towards improving thoracic surgical training, as well as enhancing preoperative planning and intraoperative guidance.},

keywords = {\*Augmented Reality

Humans

Operating Rooms

\*Thoracic Surgery

\*Thoracic Surgical Procedures

\*Virtual Reality

Augmented reality

Extended reality

Surgical simulation

Thoracic surgery

Virtual reality},

ISSN = {1569-9293 (Print)

1569-9285},

DOI = {10.1093/icvts/ivab241},

year = {2022},

type = {Journal Article}

}

@article{RN58,

author = {Bahirat, Kanchan and Lai, Chengyuan and Mcmahan, Ryan P. and Prabhakaran, Balakrishnan},

title = {Designing and Evaluating a Mesh Simplification Algorithm for Virtual Reality},

journal = {ACM Trans. Multimedia Comput. Commun. Appl.},

volume = {14},

number = {3s},

pages = {Article 63},

keywords = {virtual reality, quadric error metric, Mesh simplification},

ISSN = {1551-6857},

DOI = {10.1145/3209661},

url = {<https://doi.org/10.1145/3209661>},

year = {2018},

type = {Journal Article}

}

@article{RN13,

author = {Bakhuis, W. and Sadeghi, A. H. and Moes, I. and Maat, Apwm and Siregar, S. and Bogers, Ajjc and Mahtab, E. A. F.},

title = {Essential Surgical Plan Modifications After Virtual Reality Planning in 50 Consecutive Segmentectomies},

journal = {Ann Thorac Surg},

volume = {115},

number = {5},

pages = {1247-1255},

note = {1552-6259

Bakhuis, Wouter

Sadeghi, Amir H

Moes, Iris

Maat, Alexander P W M

Siregar, Sabrina

Bogers, Ad J J C

Mahtab, Edris A F

Journal Article

Netherlands

2022/09/10

Ann Thorac Surg. 2023 May;115(5):1247-1255. doi: 10.1016/j.athoracsur.2022.08.037. Epub 2022 Sep 6.},

abstract = {BACKGROUND: Lately, increased interest in pulmonary segmentectomy has been observed. Segmental border identification is extremely difficult on 2-dimensional computed tomography (CT). Preoperative application of virtual reality (VR) can provide better insight into patient-specific anatomy. The aim of this study was to investigate the added clinical value of 3-dimensional (3D) VR using PulmoVR for preoperative planning. METHODS: Patients with an indication for pulmonary segmentectomy were included between June 2020 and September 2021 at the Erasmus Medical Center, Rotterdam, The Netherlands. CT scans were (semi)automatically segmented to visualize lung segments, segmental arteries, veins, and bronchi. Three surgeons made a surgical plan on the basis of the conventional CT scan and subsequently analyzed the VR visualization. The primary outcome was the incidence of critical (ensuring radical resection) preoperative plan modifications. Secondarily, data on observed anatomic variation and perioperative (oncologic) outcomes were collected. RESULTS: A total of 50 patients (median age at surgery, 65 years [interquartile range, 17.25 years]) with an indication for pulmonary segmentectomy were included. After supplemental VR visualization, the surgical plan was adjusted in 52%; the tumor was localized in a different segment in 14%, more lung-sparing resection was planned in 10%, and extended segmentectomy, including 1 lobectomy, was planned in 28%. Pathologic examination confirmed radical resection in 49 patients (98%). CONCLUSIONS: This 3D VR technology showed added clinical value in the first 50 VR-guided segmentectomies because a 52% change of plan with 98% radical resection was observed. Furthermore, 3D VR visualization of the bronchovasculature, including various anatomic variations, provided better insight into patient-specific anatomy and offered lung-sparing possibilities with more certainty.},

keywords = {Humans

Adolescent

Pneumonectomy/methods

Mastectomy, Segmental

Lung/surgery

\*Lung Neoplasms/diagnostic imaging/surgery/pathology

\*Virtual Reality

Imaging, Three-Dimensional/methods},

ISSN = {0003-4975},

DOI = {10.1016/j.athoracsur.2022.08.037},

year = {2023},

type = {Journal Article}

}

@article{RN61,

author = {Blender, O},

title = {Blender—A 3D modelling and rendering package},

journal = {Retrieved. represents the sequence of Constructs1 to},

volume = {4},

year = {2018},

type = {Journal Article}

}

@inproceedings{RN64,

author = {Butnaru, T. and Girbacia, F.},

title = {Collaborative Pre-surgery Planning in a Tele-immersive Environment Using VR Technology},

booktitle = {International Conference on Advancements of Medicine and Health Care through Technology},

editor = {Vlad, Simona and Ciupa, Radu V. and Nicu, Anca I.},

publisher = {Springer Berlin Heidelberg},

pages = {9-14},

abstract = {The goal of this paper is to present a new way to use virtual reality technology to create a collaborative pre-surgery planning with purpose of reducing the time of bone surgery operations. The method presented in this paper can be used by one or more medical teams, who can collaborate remotely, immersed in a tele-immersive environment, based on networked CAVE’s systems and other stereoscopic desktop displays such as Reachin® Display [6] or classical desktop monitors with stereo capabilities. Surgeons can analyze and manipulate virtual representation of patient’s bones using 6DOF tracking devices, haptic feedback devices or voice commands. The virtual bones of patients are obtained using a 3D scanner. Surgeons have also a visual contact of which of them, using audio-video conference technologies embedded in virtual reality scene. This paper makes a wider description of the simulator, specifying the main modules and characteristics of the developed architecture. Finally, it is described in an experiment the process carried out for tele-immersive pre-surgery planning of a femur fracture.},

ISBN = {978-3-642-04292-8},

type = {Conference Proceedings}

}

@inproceedings{RN26,

author = {Chheang, V. and Saalfeld, P. and Huber, T. and Huettl, F. and Kneist, W. and Preim, B. and Hansen, C.},

title = {Collaborative Virtual Reality for Laparoscopic Liver Surgery Training},

booktitle = {2019 IEEE International Conference on Artificial Intelligence and Virtual Reality (AIVR)},

pages = {1-17},

DOI = {10.1109/AIVR46125.2019.00011},

type = {Conference Proceedings}

}

@article{RN65,

author = {Chheang, Vuthea and Fischer, Virve and Buggenhagen, Holger and Huber, Tobias and Huettl, Florentine and Kneist, Werner and Preim, Bernhard and Saalfeld, Patrick and Hansen, Christian},

title = {Toward interprofessional team training for surgeons and anesthesiologists using virtual reality},

journal = {International Journal of Computer Assisted Radiology and Surgery},

volume = {15},

number = {12},

pages = {2109-2118},

abstract = {In this work, a virtual environment for interprofessional team training in laparoscopic surgery is proposed. Our objective is to provide a tool to train and improve intraoperative communication between anesthesiologists and surgeons during laparoscopic procedures.},

ISSN = {1861-6429},

DOI = {10.1007/s11548-020-02276-y},

url = {<https://doi.org/10.1007/s11548-020-02276-y>},

year = {2020},

type = {Journal Article}

}

@article{RN6,

author = {Chheang, Vuthea and Saalfeld, Patrick and Joeres, Fabian and Boedecker, Christian and Huber, Tobias and Huettl, Florentine and Lang, Hauke and Preim, Bernhard and Hansen, Christian},

title = {A collaborative virtual reality environment for liver surgery planning},

journal = {Computers & Graphics},

volume = {99},

pages = {234-246},

abstract = {Surgical planning software is a key component in the treatment of tumor diseases. However, desktop-based systems provide only limited visualization and interaction opportunities. Moreover, collaborative planning among members of a surgical team is only possible to a limited extent. In this work, a collaborative virtual reality (VR) environment to assist liver surgeons in tumor surgery planning is presented. Our aim is to improve virtual resection planning between surgeons in a remote or co-located environment. The system allows surgeons to define and adjust virtual resections on patient-specific organ 3D surfaces and 2D image slices. Changes on both modalities are synchronized, which will enable surgeons to iterate and refine the resection surfaces quickly. In addition, a real-time risk map visualization is presented that displays safety margins around tumors. An evaluation performed by liver surgeons provides information on potential benefits, such as the possibility to visualize complex cases and assessing the safety-critical areas, applicability, and limitations for further improvement.},

keywords = {Virtual reality

Surgical planning

Medical visualization

Human-computer interaction},

ISSN = {0097-8493},

DOI = {<https://doi.org/10.1016/j.cag.2021.07.009>},

url = {<https://www.sciencedirect.com/science/article/pii/S0097849321001400>},

year = {2021},

type = {Journal Article}

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@book{RN19,

author = {Cignoni, Paolo and Callieri, Marco and Corsini, Massimiliano and Dellepiane, Matteo and Ganovelli, Fabio and Ranzuglia, Guido},

title = {MeshLab: an Open-Source Mesh Processing Tool},

volume = {1},

pages = {129-136},

DOI = {10.2312/LocalChapterEvents/ItalChap/ItalianChapConf2008/129-136},

year = {2008},

type = {Book}

}

@article{RN51,

author = {Edelmers, Edgars and Kazoka, Dzintra and Bolocko, Katrina and Sudars, Kaspars and Pilmane, Mara},

title = {Automatization of CT Annotation: Combining AI Efficiency with Expert Precision},

journal = {Diagnostics},

volume = {14},

number = {2},

pages = {185},

ISSN = {2075-4418},

url = {<https://www.mdpi.com/2075-4418/14/2/185>},

year = {2024},

type = {Journal Article}

}

@article{RN62,

author = {Einav, Yael and Gopher, Daniel and Kara, Itzik and Ben-Yosef, Orna and Lawn, Margaret and Laufer, Neri and Liebergall, Meir and Donchin, Yoel},

title = {Preoperative Briefing in the Operating Room: Shared Cognition, Teamwork, and Patient Safety},

journal = {Chest},

volume = {137},

number = {2},

pages = {443-449},

abstract = {Contemporary preoperative team briefings conducted to improve patient safety focus mainly on supplying identification details regarding the patient and the surgical procedure. Drawing on cognitive theory principles, in this study a briefing protocol was developed that presents a broader perspective model of the patient and the planned procedure. In addition to customary identification details and drug sensitivities, the new briefing also includes review of significant background information, needed equipment, planned surgery stages, and so forth. The briefing content was developed following 130 continuous, nonstructured observations conducted in gynecologic and orthopedic operating rooms. The briefing form was designed as a large poster hung in a visible position on the operating room wall. The poster guides the team members (ie, nurses, surgeons, and anesthesiologists) in their conduct. Briefing is conducted orally, and no written records are required. The number of nonroutine events (ie, situations that, if not corrected, might lead to patient harm) observed in the 130 surgeries conducted without briefing was compared with the number of events in 102 surgeries in which briefing was conducted. There was a 25% reduction in the number of nonroutine events when briefing was conducted and a significant increase in the number of surgeries in which no nonroutine event was observed. Team members evaluated the briefing as most valuable for their own work, the teamwork, and patient safety. Following the study, the new briefing format was accepted and adopted for routine use. Team briefings designed to supply a broader-perspective surgery model may be an easy-to-apply tool to reduce the number of nonroutine events during surgery and increase patient safety.},

ISSN = {0012-3692},

DOI = {<https://doi.org/10.1378/chest.08-1732>},

url = {<https://www.sciencedirect.com/science/article/pii/S0012369210600918>},

year = {2010},

type = {Journal Article}

}

@article{RN60,

author = {Farook, Taseef Hasan and Barman, Aparna and Abdullah, Johari Yap and Jamayet, Nafij Bin},

title = {Optimization of Prosthodontic Computer-Aided Designed Models: A Virtual Evaluation of Mesh Quality Reduction Using Open Source Software},

journal = {Journal of Prosthodontics},

volume = {30},

number = {5},

pages = {420-429},

abstract = {Abstract Purpose Mesh optimization reduces the texture quality of 3D models in order to reduce storage file size and computational load on a personal computer. This study aims to explore mesh optimization using open source (free) software in the context of prosthodontic application. Materials and Methods An auricular prosthesis, a complete denture, and anterior and posterior crowns were constructed using conventional methods and laser scanned to create computerized 3D meshes. The meshes were optimized independently by four computer-aided design software (Meshmixer, Meshlab, Blender, and SculptGL) to 100%, 90%, 75%, 50%, and 25% levels of original file size. Upon optimization, the following parameters were virtually evaluated and compared; mesh vertices, file size, mesh surface area (SA), mesh volume (V), interpoint discrepancies (geometric similarity based on virtual point overlapping), and spatial similarity (volumetric similarity based on shape overlapping). The influence of software and optimization on surface area and volume of each prosthesis was evaluated independently using multiple linear regression. Results There were clear observable differences in vertices, file size, surface area, and volume. The choice of software significantly influenced the overall virtual parameters of auricular prosthesis [SA: F(4,15) = 12.93, R2 = 0.67, p < 0.001. V: F(4,15) = 9.33, R2 = 0.64, p < 0.001] and complete denture [SA: F(4,15) = 10.81, R2 = 0.67, p < 0.001. V: F(4,15) = 3.50, R2 = 0.34, p = 0.030] across optimization levels. Interpoint discrepancies were however limited to <0.1mm and volumetric similarity was >97%. Conclusion Open-source mesh optimization of smaller dental prostheses in this study produced minimal loss of geometric and volumetric details. SculptGL models were most influenced by the amount of optimization performed.},

ISSN = {1059-941X},

DOI = {<https://doi.org/10.1111/jopr.13286>},

url = {<https://onlinelibrary.wiley.com/doi/abs/10.1111/jopr.13286>},

year = {2021},

type = {Journal Article}

}

@article{RN7,

author = {Ford, Jonathan M. and Decker, Summer J.},

title = {Computed tomography slice thickness and its effects on three-dimensional reconstruction of anatomical structures},

journal = {Journal of Forensic Radiology and Imaging},

volume = {4},

pages = {43-46},

abstract = {Objectives Computed Tomography (CT) scan parameters such as slice thickness have a direct impact on any 3D models derived from the volumetric data. Higher slice thickness spacing leads to loss of resolution quality in the visualizations. Materials and methods Twenty CT head scans were acquired at a 0.625mm slice thickness. These data sets were resliced a range of 1–5mm slice thicknesses. The resultant 3D models of the skull were compared using the 0.625mm model as a standard. Differences in surface area, volume and part-to-part comparison were analyzed. Results and conclusions There were significant differences in surface area, volume and part-to-part comparison analyses from the 0.625mm skulls as determined with One-way ANOVA by a p-value less than 0.05. Part-to-part comparison proved to have the greatest sensitivity for detecting geometric differences between slice thickness treatments. This study proposes using a 1.25mm maximum slice thickness when forensic practitioners require 3D reconstruction in their casework.},

keywords = {Forensic

Computed tomography

3D reconstruction

Crania

Slice thickness

Visualization

Post mortem},

ISSN = {2212-4780},

DOI = {<https://doi.org/10.1016/j.jofri.2015.10.004>},

url = {<https://www.sciencedirect.com/science/article/pii/S2212478015300204>},

year = {2016},

type = {Journal Article}

}

@misc{RN20,

author = {Garland, Michael and Heckbert, Paul S.},

title = {Surface simplification using quadric error metrics},

publisher = {ACM Press/Addison-Wesley Publishing Co.},

pages = {209–216},

keywords = {level of detail, mutiresolution modeling, non-manifold, pair contraction, surface simplification},

DOI = {10.1145/258734.258849},

url = {<https://doi.org/10.1145/258734.258849>},

year = {1997},

type = {Conference Paper}

}

@inproceedings{RN63,

author = {Gugenheimer, J. and Stemasov, E. and Frommel, J. and Rukzio, E.},

title = {A Demonstration of ShareVR: Co-Located Experiences for Virtual Reality Between HMD and Non-HMD Users},

booktitle = {2018 IEEE Conference on Virtual Reality and 3D User Interfaces (VR)},

pages = {755-756},

DOI = {10.1109/VR.2018.8446551},

type = {Conference Proceedings}

}

@article{RN57,

author = {Hanaoka, S. and Masutani, Y. and Nemoto, M. and Nomura, Y. and Miki, S. and Yoshikawa, T. and Hayashi, N. and Ohtomo, K. and Shimizu, A.},

title = {Landmark-guided diffeomorphic demons algorithm and its application to automatic segmentation of the whole spine and pelvis in CT images},

journal = {Int J Comput Assist Radiol Surg},

volume = {12},

number = {3},

pages = {413-430},

note = {1861-6429

Hanaoka, Shouhei

Orcid: 0000-0002-7496-1651

Masutani, Yoshitaka

Nemoto, Mitsutaka

Nomura, Yukihiro

Miki, Soichiro

Yoshikawa, Takeharu

Hayashi, Naoto

Ohtomo, Kuni

Shimizu, Akinobu

Journal Article

Germany

2016/12/03

Int J Comput Assist Radiol Surg. 2017 Mar;12(3):413-430. doi: 10.1007/s11548-016-1507-z. Epub 2016 Nov 30.},

abstract = {PURPOSE: A fully automatic multiatlas-based method for segmentation of the spine and pelvis in a torso CT volume is proposed. A novel landmark-guided diffeomorphic demons algorithm is used to register a given CT image to multiple atlas volumes. This algorithm can utilize both grayscale image information and given landmark coordinate information optimally. METHODS: The segmentation has four steps. Firstly, 170 bony landmarks are detected in the given volume. Using these landmark positions, an atlas selection procedure is performed to reduce the computational cost of the following registration. Then the chosen atlas volumes are registered to the given CT image. Finally, voxelwise label voting is performed to determine the final segmentation result. RESULTS: The proposed method was evaluated using 50 torso CT datasets as well as the public SpineWeb dataset. As a result, a mean distance error of [Formula: see text] and a mean Dice coefficient of [Formula: see text] were achieved for the whole spine and the pelvic bones, which are competitive with other state-of-the-art methods. CONCLUSION: From the experimental results, the usefulness of the proposed segmentation method was validated.},

keywords = {\*Algorithms

Anatomic Landmarks/\*diagnostic imaging

Cone-Beam Computed Tomography

Humans

Imaging, Three-Dimensional/\*methods

Pelvic Bones/\*diagnostic imaging

Spine/\*diagnostic imaging

Anatomical landmark

Diffeomorphic demons algorithm

Multiatlas segmentation

Pelvis

Spine},

ISSN = {1861-6410},

DOI = {10.1007/s11548-016-1507-z},

year = {2017},

type = {Journal Article}

}

@article{RN38,

author = {Lan, L. and Mao, R. Q. and Qiu, R. Y. and Kay, J. and de Sa, D.},

title = {Immersive Virtual Reality for Patient-Specific Preoperative Planning: A Systematic Review},

journal = {Surg Innov},

volume = {30},

number = {1},

pages = {109-122},

note = {1553-3514

Lan, Lucy

Orcid: 0000-0003-4474-6018

Mao, Randi Q

Qiu, Reva Y

Kay, Jeffrey

de Sa, Darren

Journal Article

Systematic Review

United States

2022/12/01

Surg Innov. 2023 Feb;30(1):109-122. doi: 10.1177/15533506221143235. Epub 2022 Nov 30.},

abstract = {Background. Immersive virtual reality (iVR) facilitates surgical decision-making by enabling surgeons to interact with complex anatomic structures in realistic 3-dimensional environments. With emerging interest in its applications, its effects on patients and providers should be clarified. This systematic review examines the current literature on iVR for patient-specific preoperative planning. Materials and Methods. A literature search was performed on five databases for publications from January 1, 2000 through March 21, 2021. Primary studies on the use of iVR simulators by surgeons at any level of training for patient-specific preoperative planning were eligible. Two reviewers independently screened titles, abstracts, and full texts, extracted data, and assessed quality using the Quality Assessment Tool for Studies with Diverse Designs (QATSDD). Results were qualitatively synthesized, and descriptive statistics were calculated. Results. The systematic search yielded 2,555 studies in total, with 24 full-texts subsequently included for qualitative synthesis, representing 264 medical personnel and 460 patients. Neurosurgery was the most frequently represented discipline (10/24; 42%). Preoperative iVR did not significantly improve patient-specific outcomes of operative time, blood loss, complications, and length of stay, but may decrease fluoroscopy time. In contrast, iVR improved surgeon-specific outcomes of surgical strategy, anatomy visualization, and confidence. Validity, reliability, and feasibility of patient-specific iVR models were assessed. The mean QATSDD score of included studies was 32.9%. Conclusions. Immersive VR improves surgeon experiences of preoperative planning, with minimal evidence for impact on short-term patient outcomes. Future work should focus on high-quality studies investigating long-term patient outcomes, and utility of preoperative iVR for trainees.},

keywords = {Humans

Reproducibility of Results

\*Virtual Reality

Neurosurgical Procedures/education

\*Neurosurgery

\*Surgeons

ergonomics and/or human factors study

image guided surgery

radiologist

simulation

surgical education},

ISSN = {1553-3506 (Print)

1553-3506},

DOI = {10.1177/15533506221143235},

year = {2023},

type = {Journal Article}

}

@article{RN48,

author = {Le Moal, J. and Peillon, C. and Dacher, J. N. and Baste, J. M.},

title = {Three-dimensional computed tomography reconstruction for operative planning in robotic segmentectomy: a pilot study},

journal = {J Thorac Dis},

volume = {10},

number = {1},

pages = {196-201},

note = {2077-6624

Le Moal, Julien

Peillon, Christophe

Dacher, Jean-Nicolas

Baste, Jean-Marc

Journal Article

China

2018/03/31

J Thorac Dis. 2018 Jan;10(1):196-201. doi: 10.21037/jtd.2017.11.144.},

abstract = {BACKGROUND: The objective of our pilot study was to assess if three-dimensional (3D) reconstruction performed by Visible Patient™ could be helpful for the operative planning, efficiency and safety of robot-assisted segmentectomy. METHODS: Between 2014 and 2015, 3D reconstructions were provided by the Visible Patient™ online service and used for the operative planning of robotic segmentectomy. To obtain 3D reconstruction, the surgeon uploaded the anonymized computed tomography (CT) image of the patient to the secured Visible Patient™ server and then downloaded the model after completion. RESULTS: Nine segmentectomies were performed between 2014 and 2015 using a pre-operative 3D model. All 3D reconstructions met our expectations: anatomical accuracy (bronchi, arteries, veins, tumor, and the thoracic wall with intercostal spaces), accurate delimitation of each segment in the lobe of interest, margin resection, free space rotation, portability (smartphone, tablet) and time saving technique. CONCLUSIONS: We have shown that operative planning by 3D CT using Visible Patient™ reconstruction is useful in our practice of robot-assisted segmentectomy. The main disadvantage is the high cost. Its impact on reducing complications and improving surgical efficiency is the object of an ongoing study.},

keywords = {Robotic surgery

ground-glass nodules

lung cancer

segmentectomy

three-dimensional computed tomography (3D CT) reconstruction},

ISSN = {2072-1439 (Print)

2072-1439},

DOI = {10.21037/jtd.2017.11.144},

year = {2018},

type = {Journal Article}

}

@inproceedings{RN12,

author = {Leibnitz, Kenji and Hoßfeld, Tobias and Wakamiya, Naoki and Murata, Masayuki},

title = {Peer-to-Peer vs. Client/Server: Reliability and Efficiency of a Content Distribution Service},

booktitle = {Managing Traffic Performance in Converged Networks},

editor = {Mason, Lorne and Drwiega, Tadeusz and Yan, James},

publisher = {Springer Berlin Heidelberg},

pages = {1161-1172},

abstract = {In this paper we evaluate the performance of a content distribution service with respect to reliability and efficiency. The considered technology for realizing such a service can either be a traditional client/server (CS) architecture or a peer-to-peer (P2P) network. In CS, the capacity of the server is the bottleneck and has to be dimensioned in such a way that all requests can be accommodated at any time, while a P2P system does not burden a single server since the content is distributed in the network among sharing peers. However, corrupted or fake files may diminish the reliability of the P2P service due to downloading of useless contents. We compare a CS system to P2P and evaluate the downloading time, success ratio, and fairness while considering flash crowd arrivals and corrupted contents.},

ISBN = {978-3-540-72990-7},

type = {Conference Proceedings}

}

@article{RN50,

author = {Lenchik, L. and Heacock, L. and Weaver, A. A. and Boutin, R. D. and Cook, T. S. and Itri, J. and Filippi, C. G. and Gullapalli, R. P. and Lee, J. and Zagurovskaya, M. and Retson, T. and Godwin, K. and Nicholson, J. and Narayana, P. A.},

title = {Automated Segmentation of Tissues Using CT and MRI: A Systematic Review},

journal = {Acad Radiol},

volume = {26},

number = {12},

pages = {1695-1706},

note = {1878-4046

Lenchik, Leon

Heacock, Laura

Weaver, Ashley A

Boutin, Robert D

Cook, Tessa S

Itri, Jason

Filippi, Christopher G

Gullapalli, Rao P

Lee, James

Zagurovskaya, Marianna

Retson, Tara

Godwin, Kendra

Nicholson, Joey

Narayana, Ponnada A

K25 AG058804/AG/NIA NIH HHS/United States

P30 AG021332/AG/NIA NIH HHS/United States

Journal Article

Research Support, N.I.H., Extramural

Systematic Review

United States

2019/08/14

Acad Radiol. 2019 Dec;26(12):1695-1706. doi: 10.1016/j.acra.2019.07.006. Epub 2019 Aug 10.},

abstract = {RATIONALE AND OBJECTIVES: The automated segmentation of organs and tissues throughout the body using computed tomography and magnetic resonance imaging has been rapidly increasing. Research into many medical conditions has benefited greatly from these approaches by allowing the development of more rapid and reproducible quantitative imaging markers. These markers have been used to help diagnose disease, determine prognosis, select patients for therapy, and follow responses to therapy. Because some of these tools are now transitioning from research environments to clinical practice, it is important for radiologists to become familiar with various methods used for automated segmentation. MATERIALS AND METHODS: The Radiology Research Alliance of the Association of University Radiologists convened an Automated Segmentation Task Force to conduct a systematic review of the peer-reviewed literature on this topic. RESULTS: The systematic review presented here includes 408 studies and discusses various approaches to automated segmentation using computed tomography and magnetic resonance imaging for neurologic, thoracic, abdominal, musculoskeletal, and breast imaging applications. CONCLUSION: These insights should help prepare radiologists to better evaluate automated segmentation tools and apply them not only to research, but eventually to clinical practice.},

keywords = {\*Algorithms

Automation

Humans

Magnetic Resonance Imaging/\*methods

Tomography, X-Ray Computed/\*methods

Ct

Mri

Machine learning

Quantitative imaging

Segmentation},

ISSN = {1076-6332 (Print)

1076-6332},

DOI = {10.1016/j.acra.2019.07.006},

year = {2019},

type = {Journal Article}

}

@article{RN49,

author = {Louis, R. G. and Steinberg, G. K. and Duma, C. and Britz, G. and Mehta, V. and Pace, J. and Selman, W. and Jean, W. C.},

title = {Early Experience With Virtual and Synchronized Augmented Reality Platform for Preoperative Planning and Intraoperative Navigation: A Case Series},

journal = {Oper Neurosurg (Hagerstown)},

volume = {21},

number = {4},

pages = {189-196},

note = {2332-4260

Louis, Robert G

Steinberg, Gary K

Duma, Christopher

Britz, Gavin

Mehta, Vivek

Pace, Jonathan

Selman, Warren

Jean, Walter C

Orcid: 0000-0001-6774-2066

Journal Article

United States

2021/06/26

Oper Neurosurg (Hagerstown). 2021 Sep 15;21(4):189-196. doi: 10.1093/ons/opab188.},

abstract = {BACKGROUND: Virtual reality (VR) allows for presurgical planning. Intraoperatively, augmented reality (AR) enables integration of segmented anatomic information with neuronavigation into the microsurgical scene to provide guidance without workflow disruption. Combining VR and AR solutions may help guide microsurgical technique to improve safety, efficiency, and ergonomics. OBJECTIVE: To describe a VR/AR platform that provides VR planning and intraoperative guidance via microscope ocular injection of a comprehensive AR overlay of patient-specific 360°/3D anatomic model aligned and synchronized with neuronavigation. METHODS: Custom 360° models from preoperative imaging of 49 patients were utilized for preoperative planning using a VR-based surgical rehearsal platform. Each model was imported to SyncAR, the platform's intraoperative counterpart, which was coregistered with Medtronic StealthStation S8 and Zeiss or Leica microscope. The model was injected into the microscope oculars and referenced throughout by adjusting overlay opacity. For anatomic shifts or misalignment, the overlay was reregistered via manual realignment with known landmarks. RESULTS: No SyncAR-related complications occurred. SyncAR contributed positively to the 3D understanding of patient-specific anatomy and ability to operate. Preoperative planning and intraoperative AR with 360° models allowed for more precise craniotomy planning and execution. SyncAR was useful for guiding dissection, identifying critical structures including hidden anatomy, understanding regional anatomy, and facilitating resection. Manual realignment was performed in 48/49 surgeries. Gross total resection was achieved in 34/40 surgeries. All aneurysm clipping and microvascular decompression procedures were completed without complications. CONCLUSION: SyncAR combined with VR planning has potential to enhance surgical performance by providing critical information in a user-friendly, continuously available, heads-up display format.},

keywords = {\*Augmented Reality

Humans

Models, Anatomic

Neuronavigation

\*Virtual Reality

Augmented reality

Craniotomy

Microscopic surgery

Navigation

Surgical planning

Virtual reality},

ISSN = {2332-4252 (Print)

2332-4252},

DOI = {10.1093/ons/opab188},

year = {2021},

type = {Journal Article}

}

@article{RN59,

author = {Luebke, D. P.},

title = {A developer's survey of polygonal simplification algorithms},

journal = {IEEE Computer Graphics and Applications},

volume = {21},

number = {3},

pages = {24-35},

ISSN = {1558-1756},

DOI = {10.1109/38.920624},

year = {2001},

type = {Journal Article}

}

@article{RN31,

author = {Mao, R. Q. and Lan, L. and Kay, J. and Lohre, R. and Ayeni, O. R. and Goel, D. P. and Sa, D.},

title = {Immersive Virtual Reality for Surgical Training: A Systematic Review},

journal = {J Surg Res},

volume = {268},

pages = {40-58},

note = {1095-8673

Mao, Randi Q

Lan, Lucy

Kay, Jeffrey

Lohre, Ryan

Ayeni, Olufemi R

Goel, Danny P

Sa, Darren de

Journal Article

Review

Systematic Review

United States

2021/07/21

J Surg Res. 2021 Dec;268:40-58. doi: 10.1016/j.jss.2021.06.045. Epub 2021 Jul 17.},

abstract = {BACKGROUND: Immersive virtual reality (iVR) simulators provide accessible, low cost, realistic training adjuncts in time and financially constrained systems. With increasing evidence and utilization of this technology by training programs, clarity on the effect of global skill training should be provided. This systematic review examines the current literature on the effectiveness of iVR for surgical skills acquisition in medical students, residents, and staff surgeons. METHODS: A literature search was performed on MEDLINE, EMBASE, CENTRAL, Web of Science and PsycInfo for primary studies published between January 1, 2000 and January 26, 2021. Two reviewers independently screened titles, abstracts, and full texts, extracted data, and assessed quality and strength of evidence using the Medical Education Research Quality Instrument (MERSQI) and Cochrane methodology. Results were qualitatively synthesized, and descriptive statistics were calculated. RESULTS: The literature search yielded 9650 citations, with 17 articles included for qualitative synthesis. The mean (SD) MERSQI score was 11.7 (1.9) out of 18. In total, 307 participants completed training in four disciplines. Immersive VR-trained groups performed 18% to 43% faster on procedural time to completion compared to control (pooled standardized mean difference = -0.90 [95% CI=-1.33 to -047, I(2)=1%, P < 0.0001]). Immersive VR trainees also demonstrated greater post-intervention scores on procedural checklists and greater implant placement accuracy compared to control. CONCLUSIONS: Immersive VR incorporation into surgical training programs is supported by high-quality, albeit heterogeneous, studies demonstrating improved procedural times, task completion, and accuracy, positive user ratings, and cost-effectiveness.},

keywords = {Clinical Competence

Humans

\*Internship and Residency

\*Simulation Training/methods

\*Students, Medical

\*Virtual Reality

Competency-based education

Medical education

Simulation training

Surgery

Surgical education

Virtual reality},

ISSN = {0022-4804},

DOI = {10.1016/j.jss.2021.06.045},

year = {2021},

type = {Journal Article}

}

@article{RN53,

author = {Menze, B. H. and Jakab, A. and Bauer, S. and Kalpathy-Cramer, J. and Farahani, K. and Kirby, J. and Burren, Y. and Porz, N. and Slotboom, J. and Wiest, R. and Lanczi, L. and Gerstner, E. and Weber, M. A. and Arbel, T. and Avants, B. B. and Ayache, N. and Buendia, P. and Collins, D. L. and Cordier, N. and Corso, J. J. and Criminisi, A. and Das, T. and Delingette, H. and Demiralp, Ç and Durst, C. R. and Dojat, M. and Doyle, S. and Festa, J. and Forbes, F. and Geremia, E. and Glocker, B. and Golland, P. and Guo, X. and Hamamci, A. and Iftekharuddin, K. M. and Jena, R. and John, N. M. and Konukoglu, E. and Lashkari, D. and Mariz, J. A. and Meier, R. and Pereira, S. and Precup, D. and Price, S. J. and Raviv, T. R. and Reza, S. M. and Ryan, M. and Sarikaya, D. and Schwartz, L. and Shin, H. C. and Shotton, J. and Silva, C. A. and Sousa, N. and Subbanna, N. K. and Szekely, G. and Taylor, T. J. and Thomas, O. M. and Tustison, N. J. and Unal, G. and Vasseur, F. and Wintermark, M. and Ye, D. H. and Zhao, L. and Zhao, B. and Zikic, D. and Prastawa, M. and Reyes, M. and Van Leemput, K.},

title = {The Multimodal Brain Tumor Image Segmentation Benchmark (BRATS)},

journal = {IEEE Trans Med Imaging},

volume = {34},

number = {10},

pages = {1993-2024},

note = {1558-254x

Menze, Bjoern H

Jakab, Andras

Bauer, Stefan

Kalpathy-Cramer, Jayashree

Farahani, Keyvan

Kirby, Justin

Burren, Yuliya

Porz, Nicole

Slotboom, Johannes

Wiest, Roland

Lanczi, Levente

Gerstner, Elizabeth

Weber, Marc-André

Arbel, Tal

Avants, Brian B

Ayache, Nicholas

Buendia, Patricia

Collins, D Louis

Cordier, Nicolas

Corso, Jason J

Criminisi, Antonio

Das, Tilak

Delingette, Hervé

Demiralp, Çağatay

Durst, Christopher R

Dojat, Michel

Doyle, Senan

Festa, Joana

Forbes, Florence

Geremia, Ezequiel

Glocker, Ben

Golland, Polina

Guo, Xiaotao

Hamamci, Andac

Iftekharuddin, Khan M

Jena, Raj

John, Nigel M

Konukoglu, Ender

Lashkari, Danial

Mariz, José Antonió

Meier, Raphael

Pereira, Sérgio

Precup, Doina

Price, Stephen J

Raviv, Tammy Riklin

Reza, Syed M S

Ryan, Michael

Sarikaya, Duygu

Schwartz, Lawrence

Shin, Hoo-Chang

Shotton, Jamie

Silva, Carlos A

Sousa, Nuno

Subbanna, Nagesh K

Szekely, Gabor

Taylor, Thomas J

Thomas, Owen M

Tustison, Nicholas J

Unal, Gozde

Vasseur, Flor

Wintermark, Max

Ye, Dong Hye

Zhao, Liang

Zhao, Binsheng

Zikic, Darko

Prastawa, Marcel

Reyes, Mauricio

Van Leemput, Koen

P41-RR14075/RR/NCRR NIH HHS/United States

P41-RR13218/RR/NCRR NIH HHS/United States

P41-EB-015902/EB/NIBIB NIH HHS/United States

U54 EB005149/EB/NIBIB NIH HHS/United States

NIHR/CS/009/011/DH\_/Department of Health/United Kingdom

P41 RR013218/RR/NCRR NIH HHS/United States

R01 EB013565/EB/NIBIB NIH HHS/United States

U01 CA154601/CA/NCI NIH HHS/United States

R01EB013565/EB/NIBIB NIH HHS/United States

R15CA115464/CA/NCI NIH HHS/United States

P41 EB015902/EB/NIBIB NIH HHS/United States

U54-EB005149/EB/NIBIB NIH HHS/United States

P41 RR014075/RR/NCRR NIH HHS/United States

R15 CA115464/CA/NCI NIH HHS/United States

Journal Article

Research Support, N.I.H., Extramural

Research Support, Non-U.S. Gov't

Review

United States

2014/12/11

IEEE Trans Med Imaging. 2015 Oct;34(10):1993-2024. doi: 10.1109/TMI.2014.2377694. Epub 2014 Dec 4.},

abstract = {In this paper we report the set-up and results of the Multimodal Brain Tumor Image Segmentation Benchmark (BRATS) organized in conjunction with the MICCAI 2012 and 2013 conferences. Twenty state-of-the-art tumor segmentation algorithms were applied to a set of 65 multi-contrast MR scans of low- and high-grade glioma patients-manually annotated by up to four raters-and to 65 comparable scans generated using tumor image simulation software. Quantitative evaluations revealed considerable disagreement between the human raters in segmenting various tumor sub-regions (Dice scores in the range 74%-85%), illustrating the difficulty of this task. We found that different algorithms worked best for different sub-regions (reaching performance comparable to human inter-rater variability), but that no single algorithm ranked in the top for all sub-regions simultaneously. Fusing several good algorithms using a hierarchical majority vote yielded segmentations that consistently ranked above all individual algorithms, indicating remaining opportunities for further methodological improvements. The BRATS image data and manual annotations continue to be publicly available through an online evaluation system as an ongoing benchmarking resource.},

keywords = {Algorithms

Benchmarking

Glioma/pathology

Humans

\*Magnetic Resonance Imaging/methods/standards

\*Neuroimaging/methods/standards},

ISSN = {0278-0062 (Print)

0278-0062},

DOI = {10.1109/tmi.2014.2377694},

year = {2015},

type = {Journal Article}

}

@book{RN52,

author = {Milletari, Fausto and Navab, Nassir and Ahmadi, Seyed-Ahmad},

title = {V-Net: Fully Convolutional Neural Networks for Volumetric Medical Image Segmentation},

pages = {565-571},

DOI = {10.1109/3DV.2016.79},

year = {2016},

type = {Book}

}

@article{RN25,

author = {Morley, L. and Cashell, A.},

title = {Collaboration in Health Care},

journal = {J Med Imaging Radiat Sci},

volume = {48},

number = {2},

pages = {207-216},

note = {1876-7982

Morley, Lyndon

Cashell, Angela

Journal Article

United States

2017/06/01

J Med Imaging Radiat Sci. 2017 Jun;48(2):207-216. doi: 10.1016/j.jmir.2017.02.071. Epub 2017 May 31.},

abstract = {Health care involves the participation of patients, family, and a diverse team of often highly specialized health care professionals. Involvement of all these team members in a cooperative and coordinated way is essential to providing exceptional care. This article introduces key concepts relating to interprofessional collaborative teamwork. Approaches to measuring and studying collaboration and evidence demonstrating the benefits of collaboration are presented. The structural, psychological, and educational factors which may determine collaborative behaviour are described. LEARNING OBJECTIVES: By the end of this CME article, participants will be able to 1. Distinguish between multifunctional and interdisciplinary teams, 2. Define collaboration in a health care setting, 3. Describe the value of collaboration to patients, staff, and organizations, 4. Understand approaches to measuring collaboration, and 5. Identify factors that determine the ability of teams to collaborate. This article is a CME article and provides the equivalent of 2 hours of continuing education that may be applied to your professional development credit system. A 20-question multiple choice quiz follows this reading, and answers can be found on page 216. Please note that no formalized credit (Category A) is available from CAMRT.},

keywords = {Collaboration

interdisciplinary

multidisciplinary

radiotherapy

teamwork},

ISSN = {1876-7982},

DOI = {10.1016/j.jmir.2017.02.071},

year = {2017},

type = {Journal Article}

}

@article{RN5,

author = {Preukschas, A. A. and Wise, P. A. and Bettscheider, L. and Pfeiffer, M. and Wagner, M. and Huber, M. and Golriz, M. and Fischer, L. and Mehrabi, A. and Rössler, F. and Speidel, S. and Hackert, T. and Müller-Stich, B. P. and Nickel, F. and Kenngott, H. G.},

title = {Comparing a virtual reality head-mounted display to on-screen three-dimensional visualization and two-dimensional computed tomography data for training in decision making in hepatic surgery: a randomized controlled study},

journal = {Surg Endosc},

volume = {38},

number = {5},

pages = {2483-2496},

note = {1432-2218

Preukschas, Anas Amin

Wise, Philipp Anthony

Bettscheider, Lisa

Pfeiffer, Micha

Wagner, Martin

Huber, Matthias

Golriz, Mohammad

Fischer, Lars

Mehrabi, Arianeb

Rössler, Fabian

Speidel, Stefanie

Hackert, Thilo

Müller-Stich, Beat Peter

Nickel, Felix

Kenngott, Hannes Götz

SFB 125/Deutsche Forschungsgemeinschaft/

Comparative Study

Journal Article

Randomized Controlled Trial

Germany

2024/03/08

Surg Endosc. 2024 May;38(5):2483-2496. doi: 10.1007/s00464-023-10615-8. Epub 2024 Mar 8.},

abstract = {OBJECTIVE: Evaluation of the benefits of a virtual reality (VR) environment with a head-mounted display (HMD) for decision-making in liver surgery. BACKGROUND: Training in liver surgery involves appraising radiologic images and considering the patient's clinical information. Accurate assessment of 2D-tomography images is complex and requires considerable experience, and often the images are divorced from the clinical information. We present a comprehensive and interactive tool for visualizing operation planning data in a VR environment using a head-mounted-display and compare it to 3D visualization and 2D-tomography. METHODS: Ninety medical students were randomized into three groups (1:1:1 ratio). All participants analyzed three liver surgery patient cases with increasing difficulty. The cases were analyzed using 2D-tomography data (group "2D"), a 3D visualization on a 2D display (group "3D") or within a VR environment (group "VR"). The VR environment was displayed using the "Oculus Rift ™" HMD technology. Participants answered 11 questions on anatomy, tumor involvement and surgical decision-making and 18 evaluative questions (Likert scale). RESULTS: Sum of correct answers were significantly higher in the 3D (7.1 ± 1.4, p < 0.001) and VR (7.1 ± 1.4, p < 0.001) groups than the 2D group (5.4 ± 1.4) while there was no difference between 3D and VR (p = 0.987). Times to answer in the 3D (6:44 ± 02:22 min, p < 0.001) and VR (6:24 ± 02:43 min, p < 0.001) groups were significantly faster than the 2D group (09:13 ± 03:10 min) while there was no difference between 3D and VR (p = 0.419). The VR environment was evaluated as most useful for identification of anatomic anomalies, risk and target structures and for the transfer of anatomical and pathological information to the intraoperative situation in the questionnaire. CONCLUSIONS: A VR environment with 3D visualization using a HMD is useful as a surgical training tool to accurately and quickly determine liver anatomy and tumor involvement in surgery.},

keywords = {Humans

\*Virtual Reality

\*Imaging, Three-Dimensional

\*Tomography, X-Ray Computed/methods

Female

Male

Hepatectomy/methods/education

Adult

Young Adult

Clinical Decision-Making

User-Computer Interface

Liver Neoplasms/surgery/diagnostic imaging

Head mounted display

Hepatic surgery training

Three dimensional visualization

Virtual reality},

ISSN = {0930-2794 (Print)

0930-2794},

DOI = {10.1007/s00464-023-10615-8},

year = {2024},

type = {Journal Article}

}

@article{RN2,

author = {Queisner, M. and Eisenträger, K.},

title = {Surgical planning in virtual reality: a systematic review},

journal = {J Med Imaging (Bellingham)},

volume = {11},

number = {6},

pages = {062603},

note = {2329-4310

Queisner, Moritz

Orcid: 0000-0001-7917-9231

Eisenträger, Karl

Orcid: 0000-0001-8090-9246

Journal Article

Review

United States

2024/04/29

J Med Imaging (Bellingham). 2024 Nov;11(6):062603. doi: 10.1117/1.JMI.11.6.062603. Epub 2024 Apr 25.},

abstract = {PURPOSE: Virtual reality (VR) technology has emerged as a promising tool for physicians, offering the ability to assess anatomical data in 3D with visuospatial interaction qualities. The last decade has witnessed a remarkable increase in the number of studies focusing on the application of VR to assess patient-specific image data. This systematic review aims to provide an up-to-date overview of the latest research on VR in the field of surgical planning. APPROACH: A comprehensive literature search was conducted based on the preferred reporting items for systematic reviews and meta-analyses covering the period from April 1, 2021 to May 10, 2023. It includes research articles reporting on preoperative surgical planning using patient-specific medical images in virtual reality using head-mounted displays. The review summarizes the current state of research in this field, identifying key findings, technologies, study designs, methods, and potential directions for future research. RESULTS: The selected studies show a positive impact on surgical decision-making and anatomy understanding compared to other visualization modalities. A substantial number of studies are reporting anecdotal evidence and case-specific outcomes. Notably, surgical planning using VR led to more frequent changes in surgical plans compared to planning with other visualization methods when surgeons reassessed their initial plans. VR demonstrated benefits in reducing planning time and improving spatial localization of pathologies. CONCLUSIONS: Results show that the application of VR for surgical planning is still in an experimental stage but is gradually advancing toward clinical use. The diverse study designs, methodologies, and varying reporting hinder a comprehensive analysis. Some findings lack statistical evidence and rely on subjective assumptions. To strengthen evaluation, future research should focus on refining study designs, improving technical reporting, defining visual and technical proficiency requirements, and enhancing VR software usability and design. Addressing these areas could pave the way for an effective implementation of VR in clinical settings.},

keywords = {planning

surgery

systematic review

virtual reality},

ISSN = {2329-4302 (Print)

2329-4302},

DOI = {10.1117/1.Jmi.11.6.062603},

year = {2024},

type = {Journal Article}

}

@article{RN33,

author = {Rahman, R. and Wood, M. E. and Qian, L. and Price, C. L. and Johnson, A. A. and Osgood, G. M.},

title = {Head-Mounted Display Use in Surgery: A Systematic Review},

journal = {Surg Innov},

volume = {27},

number = {1},

pages = {88-100},

note = {1553-3514

Rahman, Rafa

Wood, Matthew E

Qian, Long

Price, Carrie L

Johnson, Alex A

Osgood, Greg M

Orcid: 0000-0001-6271-4971

Journal Article

Systematic Review

United States

2019/09/14

Surg Innov. 2020 Feb;27(1):88-100. doi: 10.1177/1553350619871787. Epub 2019 Sep 12.},

abstract = {Purpose. We analyzed the literature to determine (1) the surgically relevant applications for which head-mounted display (HMD) use is reported; (2) the types of HMD most commonly reported; and (3) the surgical specialties in which HMD use is reported. Methods. The PubMed, Embase, Cochrane Library, and Web of Science databases were searched through August 27, 2017, for publications describing HMD use during surgically relevant applications. We identified 120 relevant English-language, non-opinion publications for inclusion. HMD types were categorized as "heads-up" (nontransparent HMD display and direct visualization of the real environment), "see-through" (visualization of the HMD display overlaid on the real environment), or "non-see-through" (visualization of only the nontransparent HMD display). Results. HMDs were used for image guidance and augmented reality (70 publications), data display (63 publications), communication (34 publications), and education/training (18 publications). See-through HMDs were described in 55 publications, heads-up HMDs in 41 publications, and non-see-through HMDs in 27 publications. Google Glass, a see-through HMD, was the most frequently used model, reported in 32 publications. The specialties with the highest frequency of published HMD use were urology (20 publications), neurosurgery (17 publications), and unspecified surgical specialty (20 publications). Conclusion. Image guidance and augmented reality were the most commonly reported applications for which HMDs were used. See-through HMDs were the most commonly reported type used in surgically relevant applications. Urology and neurosurgery were the specialties with greatest published HMD use.},

keywords = {\*Augmented Reality

Equipment Design

Fluoroscopy/instrumentation

Humans

\*Surgery, Computer-Assisted/instrumentation/methods

\*Virtual Reality

augmented reality

head-mounted display

virtual reality},

ISSN = {1553-3506},

DOI = {10.1177/1553350619871787},

year = {2020},

type = {Journal Article}

}

@article{RN54,

author = {Ranjbarzadeh, Ramin and Bagherian Kasgari, Abbas and Jafarzadeh Ghoushchi, Saeid and Anari, Shokofeh and Naseri, Maryam and Bendechache, Malika},

title = {Brain tumor segmentation based on deep learning and an attention mechanism using MRI multi-modalities brain images},

journal = {Scientific Reports},

volume = {11},

number = {1},

pages = {10930},

abstract = {Brain tumor localization and segmentation from magnetic resonance imaging (MRI) are hard and important tasks for several applications in the field of medical analysis. As each brain imaging modality gives unique and key details related to each part of the tumor, many recent approaches used four modalities T1, T1c, T2, and FLAIR. Although many of them obtained a promising segmentation result on the BRATS 2018 dataset, they suffer from a complex structure that needs more time to train and test. So, in this paper, to obtain a flexible and effective brain tumor segmentation system, first, we propose a preprocessing approach to work only on a small part of the image rather than the whole part of the image. This method leads to a decrease in computing time and overcomes the overfitting problems in a Cascade Deep Learning model. In the second step, as we are dealing with a smaller part of brain images in each slice, a simple and efficient Cascade Convolutional Neural Network (C-ConvNet/C-CNN) is proposed. This C-CNN model mines both local and global features in two different routes. Also, to improve the brain tumor segmentation accuracy compared with the state-of-the-art models, a novel Distance-Wise Attention (DWA) mechanism is introduced. The DWA mechanism considers the effect of the center location of the tumor and the brain inside the model. Comprehensive experiments are conducted on the BRATS 2018 dataset and show that the proposed model obtains competitive results: the proposed method achieves a mean whole tumor, enhancing tumor, and tumor core dice scores of 0.9203, 0.9113 and 0.8726 respectively. Other quantitative and qualitative assessments are presented and discussed.},

ISSN = {2045-2322},

DOI = {10.1038/s41598-021-90428-8},

url = {<https://doi.org/10.1038/s41598-021-90428-8>},

year = {2021},

type = {Journal Article}

}

@article{RN37,

author = {Sadeghi, A. H. and Bakhuis, W. and Van Schaagen, F. and Oei, F. B. S. and Bekkers, J. A. and Maat, Apwm and Mahtab, E. A. F. and Bogers, Ajjc and Taverne, Yjhj},

title = {Immersive 3D virtual reality imaging in planning minimally invasive and complex adult cardiac surgery},

journal = {Eur Heart J Digit Health},

volume = {1},

number = {1},

pages = {62-70},

note = {2634-3916

Sadeghi, Amir H

Orcid: 0000-0002-6118-2341

Bakhuis, Wouter

Van Schaagen, Frank

Oei, Frans B S

Bekkers, Jos A

Maat, Alexander P W M

Mahtab, Edris A F

Bogers, Ad J J C

Taverne, Yannick J H J

Journal Article

England

2020/11/23

Eur Heart J Digit Health. 2020 Nov 23;1(1):62-70. doi: 10.1093/ehjdh/ztaa011. eCollection 2020 Nov.},

abstract = {AIMS: Increased complexity in cardiac surgery over the last decades necessitates more precise preoperative planning to minimize operating time, to limit the risk of complications during surgery and to aim for the best possible patient outcome. Novel, more realistic, and more immersive techniques, such as three-dimensional (3D) virtual reality (VR) could potentially contribute to the preoperative planning phase. This study shows our initial experience on the implementation of immersive VR technology as a complementary research-based imaging tool for preoperative planning in cardiothoracic surgery. In addition, essentials to set up and implement a VR platform are described. METHODS: Six patients who underwent cardiac surgery at the Erasmus Medical Center, Rotterdam, The Netherlands, between March 2020 and August 2020, were included, based on request by the surgeon and availability of computed tomography images. After 3D VR rendering and 3D segmentation of specific structures, the reconstruction was analysed via a head mount display. All participating surgeons (n = 5) filled out a questionnaire to evaluate the use of VR as preoperative planning tool for surgery. CONCLUSION: Our study demonstrates that immersive 3D VR visualization of anatomy might be beneficial as a supplementary preoperative planning tool for cardiothoracic surgery, and further research on this topic may be considered to implement this innovative tool in daily clinical practice. LAY SUMMARY: Over the past decades, surgery on the heart and vessels is becoming more and more complex, necessitating more precise and accurate preoperative planning. Nowadays, operative planning is feasible on flat, two-dimensional computer screens, however, requiring a lot of spatial and three-dimensional (3D) thinking of the surgeon. Since immersive 3D virtual reality (VR) is an upcoming imaging technique with promising results in other fields of surgery, we aimed in this study to explore the additional value of this technique in heart surgery. Our surgeons planned six different heart operations by visualizing computed tomography scans with a dedicated VR headset, enabling them to visualize the patient's anatomy in an immersive and 3D environment. The outcomes of this preliminary study are positive, with a much more reality-like simulation for the surgeon. In such, VR could potentially be beneficial as a preoperative planning tool for complex heart surgery.},

keywords = {Cardiothoracic surgery

Innovation

Minimally invasive cardiac surgery

Preoperative planning

Virtual reality},

ISSN = {2634-3916},

DOI = {10.1093/ehjdh/ztaa011},

year = {2020},

type = {Journal Article}

}

@article{RN10,

author = {Sadeghi, A. H. and Maat, Apwm and Taverne, Yjhj and Cornelissen, R. and Dingemans, A. C. and Bogers, Ajjc and Mahtab, E. A. F.},

title = {Virtual reality and artificial intelligence for 3-dimensional planning of lung segmentectomies},

journal = {JTCVS Tech},

volume = {7},

pages = {309-321},

note = {2666-2507

Sadeghi, Amir H

Maat, Alexander P W M

Taverne, Yannick J H J

Cornelissen, Robin

Dingemans, Anne-Marie C

Bogers, Ad J J C

Mahtab, Edris A F

Journal Article

United States

2021/07/29

JTCVS Tech. 2021 Mar 16;7:309-321. doi: 10.1016/j.xjtc.2021.03.016. eCollection 2021 Jun.},

abstract = {BACKGROUND: There has been an increasing trend toward pulmonary segmentectomies to treat early-stage lung cancer, small intrapulmonary metastases, and localized benign pathology. A complete preoperative understanding of pulmonary anatomy is essential for accurate surgical planning and case selection. Identifying intersegmental divisions is extremely difficult when performed on computed tomography. For the preoperative planning of segmentectomies, virtual reality (VR) and artificial intelligence could allow 3-dimensional visualization of the complex anatomy of pulmonary segmental divisions, vascular arborization, and bronchial anatomy. This technology can be applied by surgeons preoperatively to gain better insight into a patient's anatomy for planning segmentectomy. METHODS: In this prospective observational pilot study, we aim to assess and demonstrate the technical feasibility and clinical applicability of the first dedicated artificial intelligence-based and immersive 3-dimensional-VR platform (PulmoVR; jointly developed and manufactured by Department of Cardiothoracic Surgery [Erasmus Medical Center, Rotterdam, The Netherlands], MedicalVR [Amsterdam, The Netherlands], EVOCS Medical Image Communication [Fysicon BV, Oss, The Netherlands], and Thirona [Nijmegen, The Netherlands]) for preoperative planning of video-assisted thoracoscopic segmentectomies. RESULTS: A total of 10 eligible patients for segmentectomy were included in this study after referral through the institutional thoracic oncology multidisciplinary team. PulmoVR was successfully applied as a supplementary imaging tool to perform video-assisted thoracoscopic segmentectomies. In 40% of the cases, the surgical strategy was adjusted due to the 3-dimensional-VR-based evaluation of anatomy. This underlines the potential benefit of additional VR-guided planning of segmentectomy for both surgeon and patient. CONCLUSIONS: Our study demonstrates the successful development and clinical application of the first dedicated artificial intelligence and VR platform for the planning of pulmonary segmentectomy. This is the first study that shows an immersive virtual reality-based application for preoperative planning of segmentectomy to the best of our knowledge.},

keywords = {2D, 2 dimensional

3D, 3 dimensional

AI, artificial intelligence

CT, computed tomography

DICOM, digital imaging and communication in medicine

NSCLC, non–small cell lung cancer

S, segment

VATS, video assisted thoracoscopic surgery

VR, virtual reality

lung cancer

preoperative planning

segmentectomy

video-assisted thoracoscopic surgery

virtual reality},

ISSN = {2666-2507},

DOI = {10.1016/j.xjtc.2021.03.016},

year = {2021},

type = {Journal Article}

}

@article{RN24,

author = {Sadeghi, A. H. and Mathari, S. E. and Abjigitova, D. and Maat, Apwm and Taverne, Yjhj and Bogers, Ajjc and Mahtab, E. A. F.},

title = {Current and Future Applications of Virtual, Augmented, and Mixed Reality in Cardiothoracic Surgery},

journal = {Ann Thorac Surg},

volume = {113},

number = {2},

pages = {681-691},

note = {1552-6259

Sadeghi, Amir H

Mathari, Sulayman El

Abjigitova, Djamila

Maat, Alexander P W M

Taverne, Yannick J H J

Bogers, Ad J J C

Mahtab, Edris A F

Journal Article

Review

Netherlands

2020/12/22

Ann Thorac Surg. 2022 Feb;113(2):681-691. doi: 10.1016/j.athoracsur.2020.11.030. Epub 2020 Dec 19.},

abstract = {BACKGROUND: This review aims to examine the existing literature to address currently used virtual, augmented, and mixed reality modalities in the areas of preoperative surgical planning, intraoperative guidance, and postoperative management in the field of cardiothoracic surgery. In addition this innovative technology provides future perspectives and potential benefits for cardiothoracic surgeons, trainees, and patients. METHODS: A targeted, nonsystematic literature assessment was performed within the Medline and Google Scholar databases to help identify current trends and to provide better understanding of the current state-of-the-art extended reality (XR) modalities in cardiothoracic surgery. Related articles published up to July 2020 were included in the review. RESULTS: XR is a novel technique gaining increasing application in cardiothoracic surgery. It provides a 3-dimensional and realistic view of structures and environments and offers the user the ability to interact with digital projections of surgical targets. Recent studies showed the validity and benefits of XR applications in cardiothoracic surgery. Examples include XR-guided preoperative planning, intraoperative guidance and navigation, postoperative pain and rehabilitation management, surgical simulation, and patient education. CONCLUSIONS: XR is gaining interest in the field of cardiothoracic surgery. In particular there are promising roles for XR applications in televirtuality, surgical planning, surgical simulation, and perioperative management. However future refinement and research are needed to further implement XR in the aforementioned settings within cardiothoracic surgery.},

keywords = {\*Augmented Reality

Computer Simulation/\*trends

Education, Medical, Graduate/\*methods/trends

Humans

Specialties, Surgical/\*education

Thoracic Surgery/\*education

\*Virtual Reality},

ISSN = {0003-4975},

DOI = {10.1016/j.athoracsur.2020.11.030},

year = {2022},

type = {Journal Article}

}

@article{RN45,

author = {Sampogna, G. and Pugliese, R. and Elli, M. and Vanzulli, A. and Forgione, A.},

title = {Routine clinical application of virtual reality in abdominal surgery},

journal = {Minim Invasive Ther Allied Technol},

volume = {26},

number = {3},

pages = {135-143},

note = {1365-2931

Sampogna, Gianluca

Pugliese, Raffaele

Elli, Marco

Vanzulli, Angelo

Forgione, Antonello

Journal Article

England

2017/01/14

Minim Invasive Ther Allied Technol. 2017 Jun;26(3):135-143. doi: 10.1080/13645706.2016.1275016. Epub 2017 Jan 13.},

abstract = {BACKGROUND: The advantages of 3D reconstruction, immersive virtual reality (VR) and 3D printing in abdominal surgery have been enunciated for many years, but still today their application in routine clinical practice is almost nil. We investigate their feasibility, user appreciation and clinical impact. MATERIAL AND METHODS: Fifteen patients undergoing pancreatic, hepatic or renal surgery were studied realizing a 3D reconstruction of target anatomy. Then, an immersive VR environment was developed to import 3D models, and some details of the 3D scene were printed. All the phases of our workflow employed open-source software and low-cost hardware, easily implementable by other surgical services. A qualitative evaluation of the three approaches was performed by 20 surgeons, who filled in a specific questionnaire regarding a clinical case for each organ considered. RESULTS: Preoperative surgical planning and intraoperative guidance was feasible for all patients included in the study. The vast majority of surgeons interviewed scored their quality and usefulness as very good. CONCLUSIONS: Despite extra time, costs and efforts necessary to implement these systems, the benefits shown by the analysis of questionnaires recommend to invest more resources to train physicians to adopt these technologies routinely, even if further and larger studies are still mandatory.},

keywords = {Feasibility Studies

Humans

Imaging, Three-Dimensional/\*methods

Intraoperative Care/methods

Kidney/surgery

Liver/surgery

\*Models, Anatomic

Pancreas/surgery

Preoperative Care/methods

\*Printing, Three-Dimensional

Software

Surgeons

Surveys and Questionnaires

\*Virtual Reality

Workflow

3D printing

3D reconstruction

Virtual reality

hepatobiliarypancreatic surgery

renal surgery},

ISSN = {1364-5706},

DOI = {10.1080/13645706.2016.1275016},

year = {2017},

type = {Journal Article}

}

@inproceedings{RN55,

author = {Sarker, P. and Shuvo, M. M. H. and Hossain, Z. and Hasan, S.},

title = {Segmentation and classification of lung tumor from 3D CT image using K-means clustering algorithm},

booktitle = {2017 4th International Conference on Advances in Electrical Engineering (ICAEE)},

pages = {731-736},

ISBN = {2378-2692},

DOI = {10.1109/ICAEE.2017.8255451},

type = {Conference Proceedings}

}

@article{RN36,

author = {Shirk, J. D. and Thiel, D. D. and Wallen, E. M. and Linehan, J. M. and White, W. M. and Badani, K. K. and Porter, J. R.},

title = {Effect of 3-Dimensional Virtual Reality Models for Surgical Planning of Robotic-Assisted Partial Nephrectomy on Surgical Outcomes: A Randomized Clinical Trial},

journal = {JAMA Netw Open},

volume = {2},

number = {9},

pages = {e1911598},

note = {2574-3805

Shirk, Joseph D

Thiel, David D

Wallen, Eric M

Linehan, Jennifer M

White, Wesley M

Badani, Ketan K

Porter, James R

Journal Article

Randomized Controlled Trial

Research Support, Non-U.S. Gov't

United States

2019/09/19

JAMA Netw Open. 2019 Sep 4;2(9):e1911598. doi: 10.1001/jamanetworkopen.2019.11598.},

abstract = {IMPORTANCE: Planning complex operations such as robotic-assisted partial nephrectomy requires surgeons to review 2-dimensional computed tomography or magnetic resonance images to understand 3-dimensional (3-D), patient-specific anatomy. OBJECTIVE: To determine surgical outcomes for robotic-assisted partial nephrectomy when surgeons reviewed 3-D virtual reality (VR) models during operative planning. DESIGN, SETTING, AND PARTICIPANTS: A single-blind randomized clinical trial was performed. Ninety-two patients undergoing robotic-assisted partial nephrectomy performed by 1 of 11 surgeons at 6 large teaching hospitals were prospectively enrolled and randomized. Enrollment and data collection occurred from October 2017 through December 2018, and data analysis was performed from December 2018 through March 2019. INTERVENTIONS: Patients were assigned to either a control group undergoing usual preoperative planning with computed tomography and/or magnetic resonance imaging only or an intervention group where imaging was supplemented with a 3-D VR model. This model was viewed on the surgeon's smartphone in regular 3-D format and in VR using a VR headset. MAIN OUTCOMES AND MEASURES: The primary outcome measure was operative time. It was hypothesized that the operations performed using the 3-D VR models would have shorter operative time than those performed without the models. Secondary outcomes included clamp time, estimated blood loss, and length of hospital stay. RESULTS: Ninety-two patients (58 men [63%]) with a mean (SD) age of 60.9 (11.6) years were analyzed. The analysis included 48 patients randomized to the control group and 44 randomized to the intervention group. When controlling for case complexity and other covariates, patients whose surgical planning involved 3-D VR models showed differences in operative time (odds ratio [OR], 1.00; 95% CI, 0.37-2.70; estimated OR, 2.47), estimated blood loss (OR, 1.98; 95% CI, 1.04-3.78; estimated OR, 4.56), clamp time (OR, 1.60; 95% CI, 0.79-3.23; estimated OR, 11.22), and length of hospital stay (OR, 2.86; 95% CI, 1.59-5.14; estimated OR, 5.43). Estimated ORs were calculated using the parameter estimates from the generalized estimating equation model. Referent group values for each covariate and the corresponding nephrometry score were summed across the covariates and nephrometry score, and the sum was exponentiated to obtain the OR. A mean of the estimated OR weighted by sample size for each nephrometry score strata was then calculated. CONCLUSIONS AND RELEVANCE: This large, randomized clinical trial demonstrated that patients whose surgical planning involved 3-D VR models had reduced operative time, estimated blood loss, clamp time, and length of hospital stay. TRIAL REGISTRATION: ClinicalTrials.gov identifiers (1 registration per site): NCT03334344, NCT03421418, NCT03534206, NCT03542565, NCT03556943, and NCT03666104.},

keywords = {Blood Loss, Surgical/statistics & numerical data

\*Computer Simulation

Female

Glomerular Filtration Rate

Humans

\*Imaging, Three-Dimensional

Length of Stay/\*statistics & numerical data

Male

Middle Aged

Nephrectomy/\*instrumentation/methods

Operative Time

\*Robotic Surgical Procedures

Single-Blind Method

Virtual Reality},

ISSN = {2574-3805},

DOI = {10.1001/jamanetworkopen.2019.11598},

year = {2019},

type = {Journal Article}

}

@article{RN28,

author = {Steineke, T. C. and Barbery, D.},

title = {Microsurgical clipping of middle cerebral artery aneurysms: preoperative planning using virtual reality to reduce procedure time},

journal = {Neurosurg Focus},

volume = {51},

number = {2},

pages = {E12},

note = {1092-0684

Steineke, Thomas C

Barbery, Daniela

Journal Article

United States

2021/08/02

Neurosurg Focus. 2021 Aug;51(2):E12. doi: 10.3171/2021.5.FOCUS21238.},

abstract = {OBJECTIVE: The authors sought to evaluate the impact of virtual reality (VR) applications for preoperative planning and rehearsal on the total procedure time of microsurgical clipping of middle cerebral artery (MCA) ruptured and unruptured aneurysms compared with standard surgical planning. METHODS: A retrospective review of 21 patients from 2016 to 2019 was conducted to determine the impact on the procedure time of MCA aneurysm clipping after implementing VR for preoperative planning and rehearsal. The control group consisted of patients whose procedures were planned with standard CTA and DSA scans (n = 11). The VR group consisted of patients whose procedures were planned with a patient-specific 360° VR (360VR) model (n = 10). The 360VR model was rendered using CTA and DSA data when available. Each patient was analyzed and scored with a case complexity (CC) 5-point grading scale accounting for aneurysm size, incorporation of M2 branches, and aspect ratio, with 1 being the least complex and 5 being the most complex. The mean procedure times were compared between the VR group and the control group, as were the mean CC score between the groups. Comorbidities and aneurysm conduction (ruptured vs unruptured) were also taken into consideration for the comparison. RESULTS: The mean CC scores for the control group and VR group were 2.45 ± 1.13 and 2.30 ± 0.48, respectively. CC was not significantly different between the two groups (p = 0.69). The mean procedure time was significantly lower for the VR group compared with the control group (247.80 minutes vs 328.27 minutes; p = 0.0115), particularly for the patients with a CC score of 2 (95% CI, p = 0.0064). A Charlson Comorbidity Index score was also calculated for each group, but no statistical significance was found (VR group, 2.8 vs control group, 1.8, p = 0.14). CONCLUSIONS: In this study, usage of 360VR models for planning the craniotomy and rehearsing with various clip sizes and configurations resulted in an 80-minute decrease in procedure time. These findings have suggested the potential of VR technology in improving surgical efficiency for aneurysm clipping procedures regardless of complexity, while making the procedure faster and safer.},

keywords = {\*Aneurysm, Ruptured/surgery

Humans

\*Intracranial Aneurysm/diagnostic imaging/surgery

Microsurgery

Neurosurgical Procedures

Retrospective Studies

Treatment Outcome

\*Virtual Reality

craniotomy planning

microsurgical clipping

middle cerebral artery aneurysm

virtual reality},

ISSN = {1092-0684},

DOI = {10.3171/2021.5.Focus21238},

year = {2021},

type = {Journal Article}

}

@article{RN56,

author = {Summers, R. M.},

title = {Progress in Fully Automated Abdominal CT Interpretation},

journal = {AJR Am J Roentgenol},

volume = {207},

number = {1},

pages = {67-79},

note = {1546-3141

Summers, Ronald M

Z01 CL040003-06/Intramural NIH HHS/United States

Z01 CL040004-05/Intramural NIH HHS/United States

Journal Article

Review

United States

2016/04/22

AJR Am J Roentgenol. 2016 Jul;207(1):67-79. doi: 10.2214/AJR.15.15996. Epub 2016 Apr 21.},

abstract = {OBJECTIVE: Automated analysis of abdominal CT has advanced markedly over just the last few years. Fully automated assessment of organs, lymph nodes, adipose tissue, muscle, bowel, spine, and tumors are some examples where tremendous progress has been made. Computer-aided detection of lesions has also improved dramatically. CONCLUSION: This article reviews the progress and provides insights into what is in store in the near future for automated analysis for abdominal CT, ultimately leading to fully automated interpretation.},

keywords = {Automation

Forecasting

Humans

Radiographic Image Interpretation, Computer-Assisted/\*methods

\*Radiography, Abdominal

\*Tomography, X-Ray Computed

Ct

computer-aided detection

image processing

segmentation

volumetrics},

ISSN = {0361-803X (Print)

0361-803x},

DOI = {10.2214/ajr.15.15996},

year = {2016},

type = {Journal Article}

}

@article{RN44,

author = {Thumerel, M. and Belaroussi, Y. and Prisciandaro, E. and Chermat, A. and Zarrouki, S. and Chevalier, B. and Rodriguez, A. and Hustache-Castaing, R. and Jougon, J.},

title = {Immersive Three-dimensional Computed Tomography to Plan Chest Wall Resection for Lung Cancer},

journal = {Ann Thorac Surg},

volume = {114},

number = {6},

pages = {2379-2382},

note = {1552-6259

Thumerel, Matthieu

Belaroussi, Yaniss

Prisciandaro, Elena

Chermat, Anaelle

Zarrouki, Sarah

Chevalier, Benjamin

Rodriguez, Arnaud

Hustache-Castaing, Romain

Jougon, Jacques

Journal Article

Netherlands

2022/08/14

Ann Thorac Surg. 2022 Dec;114(6):2379-2382. doi: 10.1016/j.athoracsur.2022.06.059. Epub 2022 Aug 10.},

abstract = {PURPOSE: Chest wall resections for lung cancer treatment remain difficult to plan using standard 2-dimensional computed tomography. Although virtual reality headsets have been used in many medical contexts, they have not been used in chest wall resection planning. DESCRIPTION: We compared preoperative planning of a chest wall surgical resection for lung cancer treatment between senior and resident surgeons who used an immersive virtual reality device and a 2-dimensional computed tomography. EVALUATION: Chest wall resection planning was more accurate when surgeons used virtual reality vs computed tomography analysis (28.6% vs 18.3%, P = .018), and this was particularly true in the resident surgeon group (27.4% vs 8.3%, P = .0025). Predictions regarding the need for chest wall substitutes were also more accurate when they were made using virtual reality vs computed tomography analysis in all groups (96% vs 68.5%, P < .0001). Other studied parameters were not affected by the use of the virtual reality tool. CONCLUSIONS: Virtual reality may offer enhanced accuracy for chest wall resection and reconstruction planning for lung cancer treatment.},

keywords = {Humans

\*Thoracic Wall/diagnostic imaging/surgery

Tomography, X-Ray Computed/methods

\*Lung Neoplasms/diagnostic imaging/surgery

\*Thoracic Surgical Procedures/methods

\*Thoracoplasty

Imaging, Three-Dimensional},

ISSN = {0003-4975},

DOI = {10.1016/j.athoracsur.2022.06.059},

year = {2022},

type = {Journal Article}

}

@inproceedings{RN9,

author = {Tucker, N. and Sutton, B. P. and Duncan, C. and Lu, C. and Koyejo, S. and Tsung, A. J. and Maksimovic, J. and Ralph, T. and Pieta, S. M. and Bramlet, M. T.},

title = {Fully Automated Conversion Of Glioma Clinical MRI Scans Into A 3D Virtual Reality Model For Presurgical Planning},

booktitle = {2022 Annual Modeling and Simulation Conference (ANNSIM)},

pages = {392-403},

DOI = {10.23919/ANNSIM55834.2022.9859317},

type = {Conference Proceedings}

}

@article{RN23,

author = {Ujiie, H. and Yamaguchi, A. and Gregor, A. and Chan, H. and Kato, T. and Hida, Y. and Kaga, K. and Wakasa, S. and Eitel, C. and Clapp, T. R. and Yasufuku, K.},

title = {Developing a virtual reality simulation system for preoperative planning of thoracoscopic thoracic surgery},

journal = {J Thorac Dis},

volume = {13},

number = {2},

pages = {778-783},

note = {2077-6624

Ujiie, Hideki

Yamaguchi, Aogu

Gregor, Alexander

Chan, Harley

Kato, Tatsuya

Hida, Yasuhiro

Kaga, Kichizo

Wakasa, Satoru

Eitel, Chad

Clapp, Tod R

Yasufuku, Kazuhiro

Journal Article

China

2021/03/16

J Thorac Dis. 2021 Feb;13(2):778-783. doi: 10.21037/jtd-20-2197.},

abstract = {BACKGROUND: Video-assisted thoracoscopic surgery (VATS) has become a standard approach for the treatment of lung cancer. However, its minimally invasive nature limits the field of view and reduces tactile feedback. These limitations make it vital that surgeons thoroughly familiarize themselves with the patient's anatomy preoperatively. We have developed a virtual reality (VR) surgical navigation system using head-mounted displays (HMD). The aim of this study was to investigate the potential utility of this VR simulation system in both preoperative planning and intraoperative assistance, including support during thoracoscopic sublobar resection. METHODS: Three-dimensional (3D) polygon data derived from preoperative computed tomography data was loaded into BananaVision software developed at Colorado State University and displayed on an HMD. An interactive 3D reconstruction image was created, in which all the pulmonary structures could be individually imaged. Preoperative resection simulations were performed with patient-individualized reconstructed 3D images. RESULTS: The 3D anatomic structure of pulmonary vessels and a clear vision into the space between the lesion and adjacent tissues were successfully appreciated during preoperative simulation. Surgeons could easily evaluate the real patient's anatomy in preoperative simulations to improve the accuracy and safety of actual surgery. The VR software and HMD allowed surgeons to visualize and interact with real patient data in true 3D providing a unique perspective. CONCLUSIONS: This initial experience suggests that a VR simulation with HMD facilitated preoperative simulation. Routine imaging modalities combined with VR systems could substantially improve preoperative planning and contribute to the safety and accuracy of anatomic resection.},

keywords = {Virtual reality (VR)

augmented reality (AR)

head-mounted display (HMD)

segmentectomy

video-assisted thoracoscopic surgery (VATS)},

ISSN = {2072-1439 (Print)

2072-1439},

DOI = {10.21037/jtd-20-2197},

year = {2021},

type = {Journal Article}

}

@article{RN47,

author = {Whyms, B. J. and Vorperian, H. K. and Gentry, L. R. and Schimek, E. M. and Bersu, E. T. and Chung, M. K.},

title = {The effect of computed tomographic scanner parameters and 3-dimensional volume rendering techniques on the accuracy of linear, angular, and volumetric measurements of the mandible},

journal = {Oral Surg Oral Med Oral Pathol Oral Radiol},

volume = {115},

number = {5},

pages = {682-91},

note = {2212-4411

Whyms, Brian J

Vorperian, Houri K

Gentry, Lindell R

Schimek, Eugene M

Bersu, Edward T

Chung, Moo K

P30 HD003352/HD/NICHD NIH HHS/United States

R01 DC006282/DC/NIDCD NIH HHS/United States

P30 HD03352/HD/NICHD NIH HHS/United States

R01 DC6282/DC/NIDCD NIH HHS/United States

Comparative Study

Journal Article

Research Support, N.I.H., Extramural

United States

2013/04/23

Oral Surg Oral Med Oral Pathol Oral Radiol. 2013 May;115(5):682-91. doi: 10.1016/j.oooo.2013.02.008.},

abstract = {OBJECTIVES: This study investigates the effect of scanning parameters on the accuracy of measurements from three-dimensional (3D), multi-detector computed tomography (MDCT) mandible renderings. A broader range of acceptable parameters can increase the availability of computed tomographic (CT) studies for retrospective analysis. STUDY DESIGN: Three human mandibles and a phantom object were scanned using 18 combinations of slice thickness, field of view (FOV), and reconstruction algorithm and 3 different threshold-based segmentations. Measurements of 3D computed tomography (3DCT) models and specimens were compared. RESULTS: Linear and angular measurements were accurate, irrespective of scanner parameters or rendering technique. Volume measurements were accurate with a slice thickness of 1.25 mm, but not 2.5 mm. Surface area measurements were consistently inflated. CONCLUSIONS: Linear, angular, and volumetric measurements of mandible 3D MDCT models can be confidently obtained from a range of parameters and rendering techniques. Slice thickness is the primary factor affecting volume measurements. These findings should also apply to 3D rendering using cone-beam CT (CBCT).},

keywords = {Adult

Algorithms

Alveolar Process/anatomy & histology/diagnostic imaging

Anatomic Landmarks/anatomy & histology/diagnostic imaging

Cephalometry/methods/statistics & numerical data

Child

Chin/anatomy & histology/diagnostic imaging

Humans

Image Processing, Computer-Assisted/\*methods/statistics & numerical data

Imaging, Three-Dimensional/\*methods/statistics & numerical data

Mandible/anatomy & histology/\*diagnostic imaging

Mandibular Condyle/anatomy & histology/diagnostic imaging

Multidetector Computed Tomography/instrumentation/\*methods/statistics & numerical

data

Phantoms, Imaging

Polymers

Reference Standards

Retrospective Studies

\*Tomography Scanners, X-Ray Computed},

ISSN = {2212-4403 (Print)},

DOI = {10.1016/j.oooo.2013.02.008},

year = {2013},

type = {Journal Article}

}

@article{RN30,

author = {Yiasemidou, M. and Glassman, D. and Jayne, D. and Miskovic, D.},

title = {Is patient-specific pre-operative preparation feasible in a clinical environment? A systematic review and meta-analysis},

journal = {Comput Assist Surg (Abingdon)},

volume = {23},

number = {1},

pages = {57-68},

note = {2469-9322

Yiasemidou, Marina

Glassman, Daniel

Jayne, David

Miskovic, Danilo

Journal Article

Meta-Analysis

Research Support, Non-U.S. Gov't

Systematic Review

England

2018/12/01

Comput Assist Surg (Abingdon). 2018 Dec;23(1):57-68. doi: 10.1080/24699322.2018.1495266.},

abstract = {Technical difficulty of an operation is associated with patient and disease characteristics, indicating the necessity for surgeons to exercise patient-specific preparation. Such methods have been shown to be effective in the simulation suite, however, application in a real clinical environment has been sporadic. This systematic review attempts to answer if patient-specific preparation in challenging surgical procedures is feasible. A systematic review of OvidMedline, Embase and all Evidence Based Medicine review databases, was conducted in search of studies who described surgical rehearsals in all specialties. Following the application of defined inclusion and exclusion criteria relevant data were extracted and summarised. Descriptive synthesis was performed for all included studies and meta-analysis of data was applied when possible. Of fourty-nine studies included, thirty-seven were case-series, ten were non-randomised comparative trials and two randomised controlled trials. Accuracy of applied methods ranged from 66.7 to 100% and a good outcome was seen in 60-100% of operations. Meta-analysis of studies comparing rehearsals to real procedures (same patients) showed that simulated procedures were significantly faster than real ones (SMD = -1.56 [-2.19, -0.93] p < 0.00001) but were similar in other outcomes (fluoroscopy time: SMD = -0.1 [-0.63, 0.42] p = 0.7, fluoroscopy volume: SMD = -0.43[-0.97, 0.11], p = 0.12). Meta-analysis of studies comparing pre-operative rehearsals to standard treatment (two distinct groups of patients), demonstrated that real procedures were performed quicker if pre-operative rehearsal took place (SMD = -0.47 [-0.79, -0.16], P  = 0.003) but the immediate clinical outcome was similar for practiced and not practiced operations (SMD =0.03[-0.23, 0.29], p = 0.82). Current evidence suggests that patient-specific pre-operative preparation is feasible and safe and decreases operational time.},

keywords = {Computer-Aided Design

Feasibility Studies

Humans

Image Processing, Computer-Assisted

Models, Anatomic

\*Patient-Specific Modeling

Precision Medicine

Preoperative Care/\*methods

Printing, Three-Dimensional

3D imaging

Patient-specific

simulation

surgical rehearsals},

ISSN = {2469-9322},

DOI = {10.1080/24699322.2018.1495266},

year = {2018},

type = {Journal Article}

}

@article{RN29,

author = {Zawy Alsofy, S. and Sakellaropoulou, I. and Stroop, R.},

title = {Evaluation of Surgical Approaches for Tumor Resection in the Deep Infratentorial Region and Impact of Virtual Reality Technique for the Surgical Planning and Strategy},

journal = {J Craniofac Surg},

volume = {31},

number = {7},

pages = {1865-1869},

note = {1536-3732

Zawy Alsofy, Samer

Sakellaropoulou, Ioanna

Stroop, Ralf

Evaluation Study

Journal Article

United States

2020/05/21

J Craniofac Surg. 2020 Oct;31(7):1865-1869. doi: 10.1097/SCS.0000000000006525.},

abstract = {OBJECTIVE: Tumors in the deep infratentorial region can be accessed via the supracerebellar-infratentorial (SCIT) or suboccipital-transcerebellar (SOTC) approaches in the sitting or prone position. Diagnosis of tumors in this region and review of their therapies are inseparably connected with cranial tomographic imaging. We retrospectively evaluate a cohort of patients who underwent tumor resection in this region and correlate complication rates to the literature, and evaluate the potential influence of a virtual reality (VR) visualization technique on surgery planning and strategy. METHODS: Patient files were retrospectively analyzed regarding operative performance parameters, histopathological findings, surgical outcomes, and complications. Preoperative magnetic resonance imaging scans were visualized via VR software. The influence of 3-dimensional VR images compared to 2-dimensional magnetic resonance imaging scans on surgical planning and surgical strategy was evaluated using a questionnaire. RESULTS: Ninety-three patients were included, 80% placed in a sitting and 20% in a prone position. The SCIT approach was performed in 59% patients and SOTC approach in 41%. Surgical tumor resections were associated with an overall complication rate comparable to the literature. Image presentation using VR had a significant influence on the recommended surgical approach (P = 0.02), but no influence on the recommended patient positioning (P = 0.37) or placement of craniotomy (P = 0.09). CONCLUSION: Tumor resection in the deep infratentorial region, despite frequent use of the sitting position and SCIT approach, was associated with a complication rate comparable to the literature. Preoperative surgical planning using VR technology may increase understanding of the anatomy and pathology, and thus influence operation planning.},

keywords = {Adult

Aged

Brain Neoplasms/\*surgery

\*Craniotomy/methods

Female

Humans

Imaging, Three-Dimensional

Male

Middle Aged

\*Neurosurgical Procedures/methods

Retrospective Studies

\*Virtual Reality

Young Adult},

ISSN = {1049-2275},

DOI = {10.1097/scs.0000000000006525},

year = {2020},

type = {Journal Article}

}