

Highlights and Potentials when Using the Visualization Table for Pre-operative Planning and Diagnosis in Seven Surgical and One Oncological Department – A Pilot Study at the University Hospital of Linköping

Stefan Redéen^{1,2,*}, Per Elmhester³, Roger Larsson², Lisa Lindfors³

¹Division of Surgery, Department of Clinical and Experimental Medicine, Faculty of Health Sciences, University Hospital, Linköping University, Linköping, Sweden

²Centre for Health Care Development, Clinicum, County Council of Östergötland, University Hospital, Linköping, Sweden

³Sectra Medical Systems AB, Linköping, Sweden

*Corresponding author: Stefan.Redeen@lio.se

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Abstract Advances in radiology combined with the advances in computer technology have made the 3D (three-dimensional) representation of anatomic structures easily obtainable using CT and MRI. The data sets resulting from CT and MRI examinations commonly consist of hundreds or thousands of slice images. 3D imaging processes and integrates this image data volume and extracts more meaningful, derivative images via primarily multiplanar reconstruction. The pilot study regards the use of the Visualization Table at Linköping University Hospital. This is one of the first studies including clinical doctors, now being presented by the University Hospital in Linköping, Sweden. Prior experience has shown that the visualization table provides valuable features that improve understanding of the operations field in a new way.

Keywords: visualisation, 3D imaging processes, radiology, surgery, planning

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1. Introduction

1.1. Medical Imaging and Visualization

Advances in radiology combined with the advances in computer technology have made the 3D (three-dimensional) representation of anatomic structures easily obtainable using CT and MRI. The data sets resulting from CT and MRI examinations commonly consist of hundreds or thousands of slice images. 3D imaging processes and integrates this image data volume and extracts more meaningful, derivative images via primarily multiplanar reconstruction (MPR), and direct volume rendering [1].

In the late 1970s the first software for 3D dynamic display of organs from computed tomograms (CT) was introduced [2]. Subsequently 3D imaging has been used in pre-surgical planning of the craniofacial [3], orthopedics [4], liver [5], lung [6], gastric [7], adrenal [8], and cardiac surgeries [9].

Sectra Visualization Table is built on Sectra PACS (Picture Archive and Communication System). Data from a CT or MR scan is used to render 3D representations of a

patient. By providing natural-size 3D views of patient anatomy, the visualization table helps surgical teams to localize vital anatomy (e.g. bones, vessels and muscles) before starting a procedure. By simply touching the screen, the surgeon can interact with the virtual body. The touch interaction allows the surgeon to manipulate the virtual body with the hands, as in the real surgical setting, and thus supports his or her tactile memory. To gain a better understanding of the specific patient's anatomy, users can remove layers of skin and muscle, zoom in and out, rotate, and cut through sections with just a swipe of a finger [10].

Even though 3D imaging is around since some time touch interfaces have recently become useful. In a recent study with orthopedic surgeons [11] it was demonstrated that the interactive touch-based visualization system is appropriate and useful for this application domain.

In the relatively small country as Sweden, The National Board of Health and Welfare (swe: Socialstyrelsen) have found there are 100 000 patients suffering from injuries caused in health care every year, resulting in many thousands of extra care days and an additional bill of 6 million Euro per year. Of these, 3000 deaths occur per year.

Moreover, during the world congress of Surgical training, SurgiCon, it was concluded that [12]:

- Cadaveric dissection is a high-value but diminishing resource for anatomical education and training which has been fundamental to the training of doctors and surgeons for centuries
- Collaboration between preclinical institutions of anatomy and teaching hospitals could optimize the use of existing training resources.
- Medicine and surgery must better understand how this invaluable resource may be better harnessed for optimal learning

1.2. The Visualization Table

The Sectra Visualization Table is a large, multi-touch medical display with software that facilitates interaction with 3D images of the human body created by modern computer tomography (CT) or magnetic resonance (MR) cameras. To achieve good images quality in 3D rendering one prerequisite is to have thin slices (<1 mm), and a second one is to use correct protocols in the CT or MR scanner to be able to study the specific tissues, organs and pathology.



Figure 1. Sectra Visualization Table

The users are able to intuitively zoom in, rotate or cut into the visualized body without using a scalpel or destroying the subject. This means that the same image can be used repeatedly, which is a valuable aspect in teaching younger colleagues. The idea of interacting with virtual patients is to provide a better understanding for the body's anatomy and functions, which in turn will contribute to better educated medical personnel and thus higher efficiency and safety in healthcare in the long-term. For the clinical domain this 3D technology maybe has the potential to decrease lead-times and reduced costs. It must however be noted that there is no research done on cost savings thanks to using multitouch 3D displays, but rather validated through business analysis.

A unique feature in the visualization table is that it can be connected to the radiology PACS to retrieve patient data, as a clinicians workstation, but here also providing an advanced 3D rendering and intuitive interface for multiple users.

1.3. Scope

The purpose of the pilot study was to evaluate the use of a visualization table at different surgical and one oncological clinical departments. The foreseen use was pre-operative planning, diagnosis and follow-up, for the individual or in multi-disciplinary team meetings for

knowledge transfer between professionals. Areas to evaluate include education, patient safety, efficiency and performance, i.e. does the individual or the group appreciate that this or similar tools can enhance patient safety and reduce the workload. Moreover further training in anatomy and pathology for professionals was foreseen, since successful surgery requires clinical experience but also the detailed knowledge of the target anatomy.

We wish that using this state of the art technology gives increased precise information about the anatomy of the vessels, bones, tumors and effects decision making during pre-operative planning, performing surgery and making potential time for another patient in the Health Care system.

2. Method

Ethics challenges in this study were not obvious since the ordinary clinical x-ray were used. No new or additional x-ray was taken in this study.

The pilot study regards the use of the Visualization Table at Linköping University Hospital only. Other products or sites are not included in the study.

Initially the medical simulation and development center Clinicum (www.clinicum.se) was involved with a request to participate in a clinical product development with 3D technology and the visualization table. The direction of Clinicum was gathered and discussed the educational and clinical need together with possible structure for intervention at the University hospital of Linköping in ordinary clinical health care, close to patients. It was decided to conduct a feasibility study with seven surgical departments and the oncology department. One department had previously used the visualization table in a four weeks trial.

Demonstrations at each department were conducted in spring 2012 in different phases linked to one or two departments together in a total length of three months. The following departments participated in the study: General Surgery, Urology, Gynecology, Neurosurgery, Oncology, Hand and plastic surgery, Ear Nose and Throat and the common operation ward. Approximately 15-20 doctors from each department participated, with a total of approximately 150 doctors.

The visualization table was connected to the hospital radiology PACS via a secure wireless Cross Platform Worklist connection. The visualization table was then placed at each department respectively for 2-3 weeks providing a possibility to let doctors study CT scans from their regular CT examinations as 2D images stacks and 3D reconstructions of the current cases. Worth to note is that there was no change in what sequences that was run or images that was acquired at the radiology department related to the ongoing study with the visualization table.

At a few occasions, technicians from hospitals and product experts from Sectra preloaded images to the table for quality control and direct access for doctors. These resources were also available for support and clinical demonstrations when doctors or departments needed extra support in navigation, developing appropriate presets and similar. Upon finishing the study period at each department, a questionnaire on the 3D technology at the visualization table was handed out to the head of

department. He/she collected input from colleagues and handed in a summary.

3. Results

In general, the visualization table allows for visualization of skeleton/bones, contrast-filled vessels and organs as well as soft tissues. In this study the participants (5 out of 8 departments answered) have studied tissue, structures and organs relevant for their patients, for example fractures on hip, face and leg, sinus infections, kidney stone and soft tissues as liver and spleen.

Anatomical areas studied in this study are the urinary tract with a big kidney stone, hepatic cancer, fracture of the hip face and leg, infections in maxillaries sinus in the face. All studies were in adults.

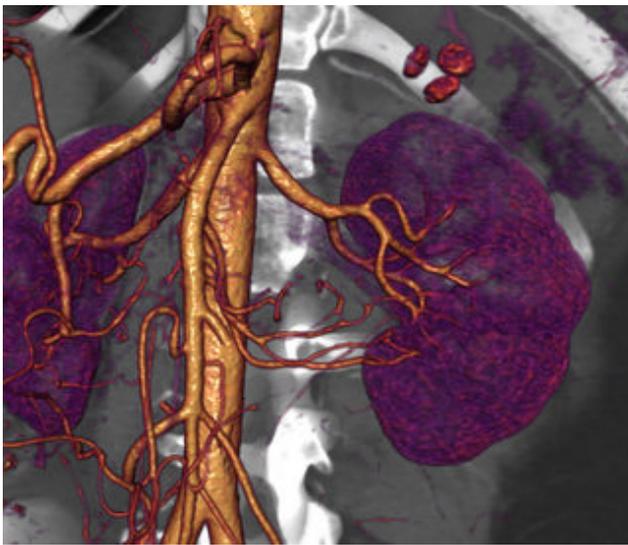


Figure 2. 3D reconstruction of CT scan.

3.1. Questions and Answers Give by the Responding Clinical Doctors at

Could pre-operative planning and follow up be easier with this 3D technology?

Six of eight respondents where positive. Two representative respondents did not value the use of this tool for pre-operative planning. Examples of use scenarios are mostly directed to better understanding of complex anatomical structures and anatomically dangerous areas while performing surgery. Sinus surgery, drawing planned surgical steps, name important anatomical details pre-operatively etc are mentioned. Moreover, organs such as glandula, and adrenal gland, being in close relation to big vessels and other potential dangerous areas are observed as surgically difficult areas where an augmented visualization like this would facilitate the pre-operative work. The visualization of vessels to/from organs are also appreciated.

Can you think of any other use area (than pre-operative planning and follow up)?

Respondents were also challenged to provide their ideas on other use areas. As an improved understanding of the patient anatomy is the red line through the responses. Responses also include several other purposes, e.g. in educating young colleagues, skills development, multi-

disciplinary team meetings, pre-operative planning and patient education.

Do you think that the visualization table / 3D technology can help increase patient safety?

There is a slight overweight towards the positive side (five yes, three no). One respondent said: The raw data is available also without the visualization table and some surgeons are used to work with CT axial images and 3D reconstructions already, indicating that the visualization table does not bring any value to these individuals. However, 62,5% of the respondents value the potential increase of patient safety and mention e.g. that increased information on the patients symptoms, anomalies and pathology increases patient safety.

Could you consider participating in a study on patient safety in the use of 3D technology?

Six respondents are positive to participate in a follow-up study, one is not interested and one did not answer.

What are the learning effects that come with using this technology in the daily clinical work, and in research?

Respondents believe that for students, residents and younger surgeons the visualization table is primarily a tool for anatomical education/learning, whereas for more experienced surgeons it becomes a tool for pre-operative planning, discussions and team meetings. The 3D visualization helps surgeons describe structures, forms and shapes that is not included in the daily vocabulary. The technology also gives a more interesting/exciting means for studying medical images. Not all respondents see a benefit though, some claim it is too cumbersome and time consuming to use and that learning effects are only a few, if any at all.

Do you have any other comments?

Some final remarks from respondents regards the study setup, proposals on the physical placement of tables at this specific hospital, and a positive "this is a good product with high potential"!

4 Discussion

The visualization table and its 3D technique are relatively new and were just made available for the market upon starting this study. This is one of the first studies including clinical doctors, now being presented by the University Hospital in Linköping, Sweden. Prior experience has shown that the visualization table provides valuable features that improve understanding of the operations field in a new way [11].

In this study, doctors from seven surgical departments and one oncology department participated. After using the table only a relatively short period of two to three weeks, doctors are overall very positive and they express a potential of the tool in improving patient safety as well as increased means for collaboration and peer to peer education and learning.

One area that needs specific attention is soft tissue imaging. The image quality is tightly related to modality type, slice thickness, and specific modality sequences, implying that radiology department should be involved in the complete workflow. Moreover, younger colleagues with less experience is assessed to benefit more from this advanced visualization technique than more experienced colleagues. This is due to the brain's capacity of learning

how to create three dimensional models, a process that needs years and thousands of images to develop.

Although several disciplines already use 3D in planning, the visualization table was still appreciated as a complement to existing and well established methods. Being observers we could see that many doctors very easily took command of the tool quickly and started to discuss clinical cases, hence appreciating the clean graphical user interface and intuitive gestures. Others rather took a passive role not wanting to touch the image but rather asking a colleague to find the best viewing angle and window-level setting.

Not mentioned in the responses from the respondents, but observed by the authors, is how quick learning curve the users have presented. After one or two short sessions with the product specialist many doctors could perform the basic steps needed for 3D viewing, such as loading the data, move, zoom, and rotate, using presets and clip planes.

It is clear, however, that there are a number of obvious interesting areas which have to be further analyzed. The pilot study is relatively general. Pre operational planning, safety and how to operate appears to be illuminated by this technique. Time savings and education/learning are other clearly interesting areas. Another aspect to study further could be to understand the reason or mechanism behind the increased learning or motivation to work with the visualization table.

Proposals for continuing work to demonstrate the possible effects of the visualization table and 3D technology in a clinical situation for specific tasks or scenarios, an approach with more time for each included participant is needed. Moreover, to further detail the values of the visualization table, it would be beneficial of performing a quantitative study.

In this study the visualization table was available for each clinic during a relatively short time. The results are consequently based on the specific patient cases that happened during the study period. The cases that were studied was not extra ordinal, but still the study does not take into account the full variety of cases that are typically taken care of at each department.. Moreover, for most of the users the visualization table was a new acquaintance. Hence the study does not consider use effects in regular and daily clinical work, but rather introduction of a new tool.

In summary, the opportunities provided with the product is very interesting and today is health care in the Western world in a clear need to improve the efficiency, safety and training staff in an optimal way, here we believe that visualization table and 3D technology will play an important role in the future.

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