Assessing the Benefits of Interactive Patient-Specific Visualisations for Patient Information

Georg Hille[1], Nico Merten[1], Steffen Serowy[2], Sylvia Glaßer[1], Klaus Tönnies[1], Bernhard Preim[1]

[1]Department of Simulation and Graphics, University of Magdeburg, Germany
[2]Department of Neuroradiology, University Hospital of Magdeburg, Germany
georg.hille@ovgu.de

Abstract. Every surgical intervention results in physical injuries. Therefore, the patient's consent is required to avoid liability in case of bodily harm. In a lot of countries a stepwise clarification process is common, combining written and verbal clarification, the latter in form of a conversation between patient and surgeon. However, many studies have shown that the quality of patient information is a weak spot in surgical treatment processes. Our approach, exemplary displayed for minimally invasive spine interventions, supports the clarification conversation by displaying intuitive, comprehensible and interactive 2D and 3D visualisations of both, the patient-specific anatomy and pathologies. Furthermore, information about surgical plans in minimally invasive interventions, like radiofrequency or microwave ablation, could be demonstrated by virtually placing applicators within the patient-customized 3D scene. Visualisation and medical application experts evaluated the contribution and usability of this tool.

1 Introduction

Every medical intervention, minimally invasive procedures included, results in physical injuries the patient's consent is required to avoid liability in case of bodily harm. The patient's approval towards interventions is crucial for any medical treatment and must always have preceded a clarification conversation between patient and surgeon.

Due to the psychological burden of patients, their ability of fully understanding the interventional plan and treatment strategy might be impaired. Though, a well-informed and therefore more independent and responsible patient contributes to a higher satisfaction regarding medical treatments [1].

In a lot of countries a stepwise clarification process is common: a combination of written information in form of leaflets and a verbal clarification by the doctor. High-quality clarification could help to overcome fear of the treatment [2] and enhance awareness and compliance [3]. As an example of use we chose therefore spine surgery as a frequent type of surgery with a high risk of severe complications depending on patient-specific spatial relations. Besides, medical specialists

like surgeons and neuroradiologists consider patient information as an integral part of their profession [4], but too often doubt their success in clarification, while tending to stick to ineffective information strategies [5]. Many studies have shown that the quality, communication and presentation, respectively of patient information is a crucial point during surgical treatment processes [3,6]. Therefore, improvements of patient information methods may also enhance the satisfaction of doctors in terms of transferring medical informations towards the patient [6].

Studies showed that multimedia contents increased patient satisfaction [7,8]. Most of them were examining the impact of multimedial patient information by films shown before the clarification conversation [7]. Their major drawback could be seen in presenting only generic, pre-recorded surgical information with no interaction possibilities and no further patient-specific information. Our approach is to improve the quality of the clarification conversation directly by involving patient-specific information in an interactive multimedia tool.

In this work, we present a 3D spine visualisation application including segmented vertebral bodies and metastases regarding pre-surgical patient information before neuroradiological interventions. Our prototypal tool, called "3D-SpineVis" should support the doctor to explain the surgical plan and treatment strategy to the patient by displaying patient-costumized anatomy and pathologies, gained e.g. through MR imaging, as well as illustrating minimally invasive instrument placing used during interventions like radiofrequency or microwave ablations. The purpose of this work was to examine whether our interactive and patient-specific tool gains benefits towards communicating and illustrating pre-surgical information during a patient-doctor conversation.

2 Materials and Methods

Our prototypal "3D-SpineVis" tool was implemented in the medical image processing and visualisation environment MeVisLab[1]. It combines original pre-interventional image data, such as MR or CT images and segmentations of anatomical structures or tissues like bones and metastasis (Fig. 2).

In this paper, we exemplary demonstrate our approach for a pre-surgical clarification support before radiofrequency ablation of vertebral metastases. Therefore, we combined pre-interventionally acquired MR images of the spine with a semi-automatical vertebral body segmentation according to the method presented by Hille et al. [9] and a manual metastases segmentation. These information were jointly aligned to display both the original MR images, as a 3D volume with freely selectable and orientable clip planes, the vertebral body and metastases segmentations as 3D volumes and contour overlays within the MRI data. The visualisation can be adjusted by opacity and illumination and, therefore, different foci of attention could be represented. Next to the 3D visualisation a second image viewer is placed, displaying the MRI data slice by sclice. With one click within a browseable 2D MRI data set with overlayed vertebral body and

[1] *http://www.mevislab.de*, last access 11/04/2016

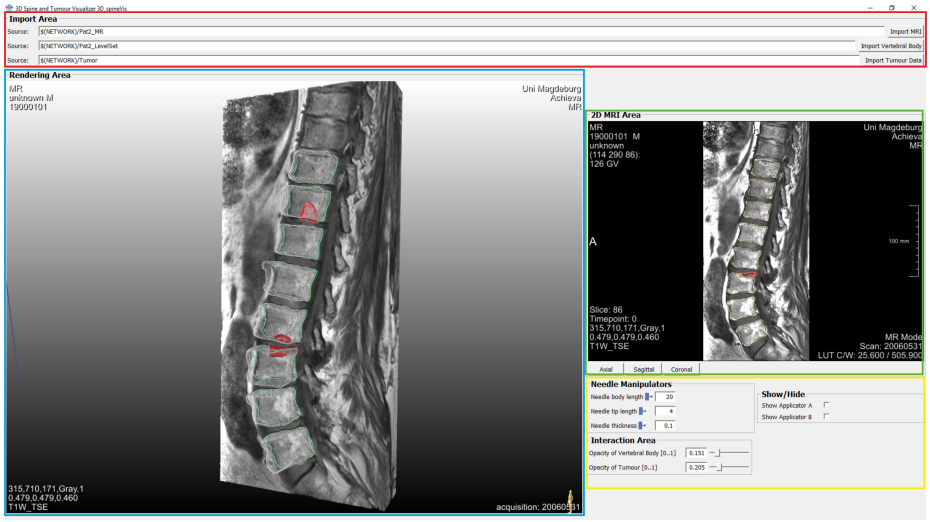


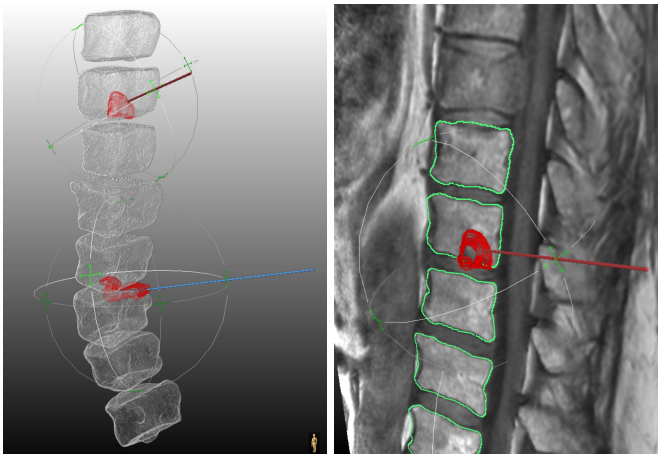
Fig. 1. The GUI of our prototypal "3D-SpineVis" application. On the top one can import the MRI or CT scans and the corresponding vertebral body and tumor/metastases segmentations (red box). The large viewer on the left is for spatially exploring the volume-rendered scene (blue box). Herein, a clinical expert could comprehensibly explain patient-specific spatial relations and give insight how to perform an ablative intervention with interactive models of minimally invasive applicators. On the upper right, both the original image data with super-imposed segmentation contours could be explored and the applicator models could be placed here per one-click (green box). In the yellow box in the lower right corner opacities of the segmented 3D objects could be adjusted (vertebral bodies in white, metastases in red), and it offers the option to show or hide the applicator models.

metastases segmentation contours, one can initially place an abstracted model of a minimally invasive intervention applicator. The user can rotate the applicator with the needle tip orientated towards the clicked voxel within the 3D scene to demonstrate potential patient-customized intervention plans (Fig. 2).

We asked five visualisation and medical application field experts to evaluate our tool. Since it should primarily gain benefits towards patients, it makes sense to ask non-medical persons. We asked them to assess the following eight statements, while ranking their agreeing or disagreeing in a five-point Likert scale from strongly disagree (- -) to stronlgy agree (++):

Q1) Multimedia-supported patient information enhance the quality of the clarification process.
Q2) Presenting *patient-customized information* constitutes a gain towards comprehension and clarification.
Q3) Presenting *interactive information* constitutes a gain towards comprehension and clarification.

Q4) The presented prototypal tool is *intuitive* to use to display image-based information, like anatomical structures and pathologies.
Q5) The presented prototypal tool displays image based information, like anatomical structures and pathologies *comprehensible*.
Q6) In case that patients see generic multimedia material like pre-recorded videos prior to the patient-doctor conversation,
  a) presenting patient-customized and interactive information in the patient-doctor conversation *has a benefit over* generic media.
  b) presenting patient-customized and interactive information in the patient-doctor conversation *is a suitable addition* to generic media.
Q7) The presented prototypal tool is an contribution regarding information communication and visualisation within a patient clarification conversation.



(a) (b)

Fig. 2. Details of the volume-rendered scene with applicator model tips placed within the metastases. It is possible to display only the segmented 3D objects with the placed applicator models (a), as well as to add further anatomical and structural information by displaying also the original MRI data (b). Therefore, the user could balance between simplified and more complex visualisations.

3 Results

Figure 3 shows the results of our evaluation. They show the opinions of our evaluatees as visualisation and medical application field experts, as well as potential patients. Exceptionless, every evaluatee considers multimedia support a quality enhancement towards the clarification process (Q1). The majority of the surveyed persons strongly agree that including interactively explorable

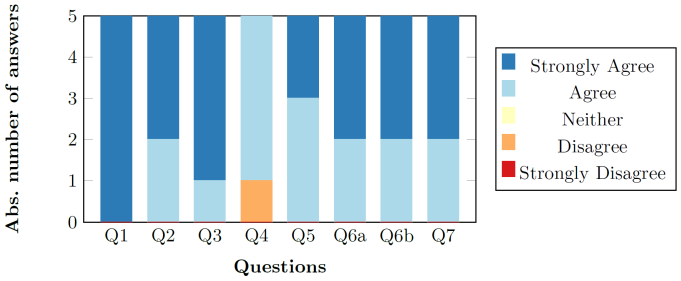


Fig. 3. The results of our survey.

and patient-specific information improves comprehension and clarification (Q2 and Q3). Regarding the intuitivity and comprehensibility of the presented "3D-SpineVis" tool (Q4 and Q5), only one evaluatee stated it as not intuitive, but comprehensible. Besides, the remaining evaluatees agreed with both statements. Furthermore, the evaluatees assessed our tool as a suitable addition to generic media (Q6b), like pre-conversational shown videos, or even as superior (Q6a). Overall, our presented tool was evaluated from all surveyed persons as a possible contribution during a patient information conversation (Q7).

4 Discussion

The desire for a visual support during the clarification conversation reflects the contemporary trend towards technical assistance, to enhance vividness and comprehensibility of medical informations [8]. This assessment was also confirmed by our evaluatees, who unanimously stated that multimedia support would qualitatively improve patient information procedures. Furthermore, it was evaluated that both patient-specific and interactive visual information would increase the communication quality. While examining potential benefits of media support in research, so far, mostly films shown before the clarification conversation were discussed [7,8]. Possible drawbacks of such films could be seen in their generic and non-interactive features. Hence, our evaluatees evaluated patient-customized and interactive information as a suitable addition to generic video material or even superior to it. To become a reasonable support for the patient-doctor conversation, both the operability of every multimedia tool and the presentation of information have to be intuitive and comprehensible. Our prototypal "3D-SpineVis" tool was largely assessed to be intuitive to handle, except from one evaluatee who disagreed. However, one must consider that user expertise increases with practise time and the prototypal state of our tool. Furthermore, it was found comprehensible regarding information display. Overall, our approach was evaluated as a possible contribution concerning information communication and visualisation within a patient information conversation.

The prototypal "3D-SpineVis" tool that we presented in this work was evaluated from all surveyed persons as a contribution towards communication and

comprehensibility of patient information by supporting the patient-doctor conversation with specific and interactional visualisations of patient anatomy and pathology. Additionally, the surgeon could provide an insight into the patient-specific surgical plan by placing models of minimally invasive interventional instruments.

Our approach offers different links to future work, e.g. simulation of treatment methods, like heatmaps of ablation procedures or further improvements of the 3D visualisation. Reasonable attempts like adaptive cutaways of volume render scenes, presented by Li et al. [10], could enhance the illustration of details, like metastases and medical applicator placement, while maintaining the overview and orientation within comprehensive anatomical models.

Acknowledgements This work was supported by the German Ministry of Education and Research (13GW0095A) within the STIMULATE research campus.

References

1. Sechrest R, Henry D. Computer-based patient education: observations on effective communication in the clinical setting. The Journal of Biocommunication. 1995;23(1):8–12.
2. Anzenberger P, Jedinger O, Zarhuber K. Design and Development of a multilingual multimedia based presurgical Information and Clarification System for Tablet Computers. In: Proceedings of the (IADIS), International Conference on e-Health; 2012. .
3. Ha JF, Longnecker N. Doctor-patient communication: a review. The Ochsner Journal. 2010;10(1):38–43.
4. Keulers B, Scheltinga M, Houterman S, Van Der Wilt G, Spauwen P. Surgeons underestimate their patients' desire for preoperative information. World Journal of Surgery. 2008;32(6):964–970.
5. Keulers BJ, Welters CF, Spauwen PH, Houpt P. Can face-to-face patient education be replaced by computer-based patient education? A randomised trial. Patient Education and Counseling. 2007;67(1):176–182.
6. Ong LM, De Haes JC, Hoos AM, Lammes FB. Doctor-patient communication: a review of the literature. Social Science & Medicine. 1995;40(7):903–918.
7. Evrard S, Mathoulin-Pelissier S, Larrue C, Lapouge P, Bussieres E, De Lara CT. Evaluation of a preoperative multimedia information program in surgical oncology. European Journal of Surgical Oncology (EJSO). 2005;31(1):106–110.
8. Eggers C, Obliers R, Koerfer A, Thomas W, Koehle K, Hoelscher AH, et al. A Multimedia Tool for the Informed Consent of Patients prior to Gastric Banding. Obesity. 2007;15(11):2866–2873.
9. Hille G, Glaßer S, Tönnies K. Hybrid Level-Sets for Vertebral Body Segmentation in Clinical Spine MRI. Procedia Computer Science. 2016;90:22–27.
10. Li W, Ritter L, Agrawala M, Curless B, Salesin D. Interactive Cutaway Illustrations of Complex 3D Models. ACM Transactions on Graphics (TOG). 2007;26(3):31.