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1. Introduction

Every physician using computer for diagnostic and therapeutic purposes should know that images are processed by use of graphic and computer systems, as well as by specialized program systems, in order to better present the anatomy of a particular part of the body with identified diseased areas (Ecke et al., 1998; Urban et al., 1998). The possibility of exact preoperative, non-invasive visualization of the spatial relationships of anatomic and pathologic structures, including extremely fragile ones, size and extent of pathologic process, and of precisely predicting the course of surgical procedure, allows the surgeon to achieve considerable advantage in the preoperative examination of the patient and to reduce the risk of intraoperative complications (Knezović et al., 2007), all this by use different virtual reality (VR) methods (Fig.1).

Beside otorhinolaryngology, this has also been used in other fields (Klimek et al., 1998; Hassfeld et al., 1998). The more so, in addition to educational applications, virtual endoscopy (VE), virtual surgery (VS), application of 3D models, etc., has offered us the possibility of preoperative planning in rhinology (sinus surgery), and has become a very important segment in surgical training and planning of each individual surgical intervention. These analyses are becoming routine procedures in other otorhinolaryngology, oral, maxillofacial and plastic surgery, etc.

Classical endoscopic procedures performed with rigid endoscopes are invasive and often uncomfortable for patients, and some of them may have serious side effects such as perforation, infection and hemorrhage (Belina et al., 2008). VE is a new method of diagnosis...
using computer processing of 3D image datasets (such as 2D multi slice computed tomography - MSCT and/or MRI scans) to provide simulated visualizations of patient specific organs similar or equivalent to those produced by standard endoscopic procedures (Rob, 2000; Wickham et al., 1994). Development of new computer techniques and fly through algorithms offer valuable non-invasive additional tools in diagnostics and preoperative planning in otorhinolaryngology (Fig.2.). Virtual endoscopy visualization avoids the risks associated with real endoscopy, and when used prior to performing an actual endoscopic exam can minimize procedural difficulties and decrease the rate of morbidity, especially for endoscopists in training (Robb, 2000), which was proved in our first Croatian 3D computer assisted- functional endoscopic sinus surgery (3D-CA-FESS) in June 3, 1994 (Klapan et al., 1997).

Definitely, the basic goal of 3D-computer assisted (3D-CA) support in diagnostic and surgical activities is to achieve safer surgical procedure using new computer and medical technologies in surgical (Anon et al., 1998) and/or telesurgical procedures (Fig.3.), and provide visualization of the anatomy as well the pathology in the 2D as well as in the form of 3D-models. Using our own approach in computer assisted-endoscopic surgery, we were able to "look inside" the patient during the real surgical procedure. According to our original idea, the computer network, essential for computer collaboration between surgical sites for telesurgical purposes, has to be built in parallel to the video network. Every
Fig. 2. An example of 3D-computer assisted navigation surgery of the nose and paranasal sinuses with simulation and planning of the course of subsequent endoscopic operation per viam VE which overcomes some difficulties of conventional endoscopy, such as “standard” FESS or tele-FESS (taken with permission of Klapan Medical Group Polyclinic, Zagreb, Croatia)

Telesurgical site must have compliant collaboration software. On computer workstations, all sites have computed tomography (CT) images and 3D models with appropriate movies, and then the consultant, an experienced surgeon, assists the less experienced surgeon to reach the pathology in the operating field.

This kind of our Tele-3D-computer assisted surgery (Tele-3D-CAS) has to enable less experienced surgeons to perform critical surgeries using guidance and assistance from a remote, experienced surgeon. In telesurgery, more than two locations can be involved; thus less experienced surgeon can be assisted by one, two or more experienced surgeons, depending on the complexity of the surgical procedure. Our Tele-3D-CAS provides also the transfer of computer data (images, 3D-models) in real time during the surgery and, in parallel, of the encoded live video signals. Through this network, the two encoded live video signals from the endocamera and operation room camera have to be transferred to the remote locations involved in the telesurgery/consultation procedure (Klapan et al., J Telemed Telecare, 2002).

The first kind of our Tele-3D-C-FESS took place between two locations in the city of Zagreb, 10 km apart, with interactive collaboration from a third location. A surgical team carrying out an operative procedure at the Šalata ENT Department, Zagreb University School of Medicine and Zagreb Clinical Hospital Center, received instructions, suggestions and guidance through the procedure by an expert surgeon from an expert center. The third
Fig. 3. Our tele-3D-computer assisted surgery of the nose and paranasal sinuses realized during our 3D computer assisted-FESS in June 3, 1994., proved the main advantage of VE and/or tele-VE that there are no restrictions on the movement of virtual endoscope prior the real procedure, and requires no hospitalization (taken with permission from Klapan et al., Otolaryngology Head Neck Surg, 2002 and Klapan Medical Group Polyclinic, Zagreb, Croatia).

Active point was the Faculty of Electrical Engineering and Computing. The 2nd Tele-3D-C-FESS took place between two locations, two cities in Croatia (Osijek and Zagreb, 300 km apart). The surgical team carrying out an operative procedure at the ENT Department, Osijek Clinical Hospital, received instructions, suggestions and guidance through the procedure by an expert surgeon and radiologist from the Expert Center in Zagreb. This Tele-3D-C-FESS surgery, performed as described above, was successfully completed in 25-30 minutes.

Taking into account the opinion of the leading world authorities in endoscopic surgery, we believe that each endoscopic operation is a demanding procedure, including those described in the first two Tele-3D-C-FESS surgeries presented. Nevertheless, we would like to underline herewith that ordinary, and occasionally even expert surgeons may need some additional intraoperative consultation (or VE/3D support), for example, when anatomical markers are lacking in the operative field due to trauma (war injuries) or massive polypous lesions/normal mucosa consumption, bleeding, etc. Now, imagine that we can substitute artificially generated sensations for the real standard daily information received by our senses. In this case, the perception system in humans could be deceived, creating an impression of another ‘external’ world around the man (e.g., 3D navigation surgery). In this way, we could replace the true reality with the simulated reality that enables precise, safer and faster diagnosis as well as surgery. All systems of simulated reality share the ability to offer the user to move and act within the apparent worlds instead of the real world.

What do experts think about additional support per viam computer assisted reconstruction of the anatomy and pathology of the head and neck; what is the truth and level of reliability?
Definitely, the presentation of image data in such a way enables the operator not only to explore the inner wall surfaces but also to navigate inside the virtual organs extracted from MSCT and/or MR images of nasal cavity, paranasal sinuses and skull base, and in combination with in-space skull bone rendering, offers plastic and accurate additional 3D information for head and neck surgeon in combination with classical 2D black and white CT images (Belina et al., 2008). Interactive display of correlated 2D and 3D data in a four-window format may assist the endoscopist in performing various image guided procedures. In comparison with real endoscopy, the VE is completely non-invasive. It is possible to repeat the same procedure several times, therefore it may be a valuable tool for training, as well as the interactive control of all virtual camera parameters, including the field-of-view, and the viewing as opposed to the extend of lesions within and beyond the wall which gives the potential to stage tumors by determining the location and the extent of transmural extension (Belina et al., 2008). In the nasal or sinus cavity, VE can clearly display the anatomic structure of the paranasal sinuses (Di Rienzo et al., 2003), nasopharyngeal cavity and upper respiratory tract, revealing damage to the sinus wall caused by a bone tumor or fracture (Tao et al., 2003; Belina et al., 2009), and use the corresponding cross-sectional image or multiplanar reconstructions to evaluate structures outside the sinus cavity. A major disadvantage of VE is its inability to make an impact on operating room performance, as well as the considerable time consumption (Caversaccio et al., 2003), to evaluate the mucosal surface (Belina et al., 2008), or to provide a realistic illustration of the various pathologic findings in cases with highly obstructive sinonasal disease (Bisdas et al., 2004).

Even more, our vision of 3D-CA-navigation surgery and/or tele-3D-CA-navigation surgery allows surgeons not only to see and transfer video signals but also to transfer 3D computer models and surgical instrument movements with image/3D-model manipulations in real time during the surgery (Šimičić et al., 1998) (Fig. 23). Considering the specificities and basic features of 3D-CA-navigation surgery and tele-3D-CAS, we believe that this type of surgery would be acceptable to many surgeons all over the world for the following reasons: a) the technology is readily available in collaboration with any telecom worldwide, b) the improved safety and reduced cost will allow the inclusion of a greater number of patients from distant hospital institutions in such a telesurgical expert system, c) the “presence” of leading international surgical experts as tele-consultants in any OR in the world will thus be possible in the near future, which will additionally stimulate the development of surgery in all settings; and d) the results obtained in the tele-3D-CAS project in Croatia are encouraging and favor the further development of the method. The possibility of data analysis and storage in the 3D form and development of 3D centers at clinical institutions, as well as the development of the surgery using a remote-controlled robots (Vilbert et al., 2003) should provide a new quality in proper training of future surgeons in 3D-CAS as well as tele-3D-CAS activities (www.mef.hr/MODERNRHINOLOGY and www.poliklinika-klapan.com).

Finally, modelling of the biological material and tissue properties is an important field of research. In the future, we can expect a new generation of diagnostic imaging techniques that use simulated reality techniques for effective visualization of organ anatomy and function. Such systems will enable not only better medical diagnosis but also more appropriate intervention.
Fig. 23. Different VR applications can be applied for preoperative analysis, intraoperative surgery (as well as postoperative training and education), and completely familiarize the surgeon with endoscopic anatomy and pathology in the real operation (taken with permission from Klapan et al. Coll Anthrop 2008., and Klapan Medical Group Polyclinic, Zagreb, Croatia)
5. References


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Technological advancement in graphics and other human motion tracking hardware has promoted pushing "virtual reality" closer to "reality" and thus usage of virtual reality has been extended to various fields. The most typical fields for the application of virtual reality are medicine and engineering. The reviews in this book describe the latest virtual reality-related knowledge in these two fields such as: advanced human-computer interaction and virtual reality technologies, evaluation tools for cognition and behavior, medical and surgical treatment, neuroscience and neuro-rehabilitation, assistant tools for overcoming mental illnesses, educational and industrial uses. In addition, the considerations for virtual worlds in human society are discussed. This book will serve as a state-of-the-art resource for researchers who are interested in developing a beneficial technology for human society.

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