The Potential Application of Virtual, Augmented, and Mixed Reality in Neurourology

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The application of virtual/augmented reality (VR/AR) in medicine and healthcare has been evolving more actively than we are aware. Roven et al. [1] reported the application of VR to plan and perform surgery in 1996 and explained 3 areas such as using virtual humans for training, the fusion of virtual humans with real humans for performing surgery, and virtual telemedicine-based environments for training multiple players.

In urology, there have been several studies on applying VR/AR for training and performing surgery. For example, the fusion of 3-dimensional reconstruction images of the kidney, bladder, prostate, and pelvic anatomy and VR technology can be used to perform a virtual dissection before the real surgery [2]. In addition, there are several urologic training simulators using the VR technique such as the digital rectal examination to detect prostate cancer, transurethral resection of the prostate, flexible ureteroscopy, and laparoscopic and robotic surgery [3-6]. Recently, several studies observed the benefit of partial nephrectomy using AR because accurate image-guided tumor resection was possible by obtaining better information about the tumor and anatomy of the surrounding vasculature [7].

However, the application of VR/AR had been limited in the areas such as training simulators and performing surgery in urology. Therefore, a novel application of VR/AR in neurourology is necessary after reviewing and understanding the VR/AR technology. A significant improvement in the VR/AR technology allows creation of more life-like experiences by increasing the level of detail and precision this can therefore be applied professional fields [8]. In the area of neuroscience and psychiatry, VR/AR based behavior rehabilitation of patients experienc-

ing various types of phobias can be performed through biofeedback and real-time modification of objects in the virtual environment according to the patients' interactions. Biofeedback is also one of the treatment methods to manage overactive bladder (OAB). To increase the treatment effect, it is important to exercise the exact pelvic floor muscle. The fusion of biofeedback and AR may increase the treatment effect by means of improving the communication with patients and helping them visualize the biofeedback process. In addition, it would help patients to exercise the exact pelvic floor muscle to reduce OAB symptoms. The application of AR in biofeedback for the treatment of OAB is only one example, and the potential application of AR in neurourology is immense.

We have noted that certain patients experience different symptoms in the clinic and in daily life; therefore, it is important to know what occurs in their daily life. A neurourological approach based on VR/AR may be able to reflect the real symptoms of patients in daily life. Moreover, the information obtained from these data could help reduce their real symptoms and maintain their normal daily life.

The most important merit of VR/AR is that it can interact with the patient; more importantly, doctors and patients can interact with each other using the VR/AR technology. Therefore, the new approach using VR/AR is expected to enrich the field of neurourology.

• **Conflict of Interest:** No potential conflict of interest relevant to this article is reported.

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REFERENCES

1. Roven JM, Soltanian H, Redett RJ. Evolution of virtual reality. *IEEE Eng Med Biol Mag* 1996;15:16-22.
2. Shah J, Mackay S, Vale J, Darzi A. Simulation in urology: a role for virtual reality? *BJU Int.* 2001;88:661-5.
3. Burdea G, Patounakis G, Popescu V, Weiss RE. Virtual reality-based training for the diagnosis of prostate cancer. *IEEE Trans Biomed Eng* 1999;46:1253-60.
4. Ballaro A, Briggs T, Garcia-Montes F, MacDonald D, Emberton M, Mundy AR. A computer generated interactive transurethral prostatic resection simulator. *J Urol* 1999;162:1633-5.
5. Preminger GM, Babayan RK, Merrill GL, Raju R, Millman A, Merrill JR. Virtual reality surgical simulation in endoscopic urologic surgery. *Stud Health Technol Inform* 1996;29:157-63.
6. Taffinder N, Sutton C, Fishwick RJ, McManus IC, Darzi A. Validation of virtual reality to teach and assess psychomotor skills in laparoscopic surgery: results from randomised controlled studies using the MIST VR laparoscopic simulator. *Stud Health Technol Inform* 1998;50:124-30.
7. Hughes-Hallett A, Mayer EK, Marcus HJ, Cundy TP, Pratt PJ, Darzi AW, et al. Augmented reality partial nephrectomy: examining the current status and future perspectives. *Urology* 2014;83:266-73.
8. Hamacher A, Kim SJ, Cho ST, Pardeshi S, Lee SH, Eun SJ, et al. Application of virtual, augmented, and mixed reality to urology. *Int Neurourol J* 2016;20:172-81.