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Editorial

3-D Printing in Urology

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Three-Dimensional (3D) printing is an additive manufacturing process that was introduced first in 1986 with photosensitive resin polymerized by UV light. In urology, 3D printing has been used for several purposes to help the surgeon better understand anatomy, sharpen his/her skills, and guide the identification of lesions and their relationship with surroundings [1]. 3D-printed models were mostly employed for the management of renal tumors and lithiasis. They provided enhanced visualization of structures and the possibility to perform procedures rehearsals which seemed to improve surgical procedures [2]. The ultimate aim of 3D bioprinting will be to produce transplantable solid organs, such as kidneys, but work in this area is still in its infancy with many challenges remaining [3], as clinicians, we should be aware of the potential errors of 3D printing technology, and the basics of patient-centered clinical decision-making should always be paramount [4].

Studies demonstrated improved surgeon confidence, operative performance, and optimized patient outcomes including high levels of patient satisfaction. Realistic, accurate, and reasonably priced models can currently be generated within hours using standard desktop 3D printers. As Urologists continue to rapidly diversify and iterate upon this adaptive modality, the benefits in patient outcomes will likely outpace the diminishing drawbacks, and we may well see the next revolution in surgical education, robotic techniques, and personalized medicine concurrently [5] Although 3D organ printing holds much promise for patients suffering from renal failure, the technology remains in the development phases. The replication of complicated venous systems embedded in most organs remains a significant hurdle and makes organ bio-fabrication more complicated than, for instance, the 3D printing of simple mechanical parts. The future holds the prospect of printing 3D mini-organs, which will fulfill only a certain lacking function of a major organ and would not necessitate replacing the entire organ, thereby avoiding invasive surgery. Similarly, there is the prospect of in situ fabrication, where a replacement organ would be directly printed into a patient while they undergo a surgical procedure Thus, the technology continues to advance at an astonishing rate, targeting human problems that were previously deemed to be hopeless. Despite the challenges that remain, as time progresses, sustained research and development may continue to yield groundbreaking discoveries in 3D bio-fabrication to improve the lives of those suffering from renal failure. [6] As 3D printing and modeling continue to have a greater impact on patient care, confirming anatomical accuracy should be introduced as a quality control measure before use for patient care [7].

The area of 3D printing in Urology shows promising results, but further research is required and cost reduction must occur before clinicians fully embrace its use. As costs continue to decline and the diversity of materials continues to expand, research and clinical utilization will increase. Recent advances have demonstrated the potential of this technology in the realms of education and surgical optimization. The generation of personalized organs using 3D printing scaffolding remains the ‘holy grail’ of this technology [8]. In vesico-ureteric reflux, the 3D-printed Fish Tank Simulation Model proved to be a valuable, high-fidelity, easily accessible, cost-effective, hygienic, and domestic-use training tool for pediatric surgeons/urologists conducting the procedure. The model’s user-friendly design and realistic environment enhanced learning opportunities for trainees, regardless of their experience level or training status. Nevertheless, further development is necessary, particularly in enhancing the realism of the ureteral hiatus and reproducing more complex anatomy, to make it beneficial for the training of advanced surgeons [9].

In training, surgical simulation models were used in robotic surgery education. There are six major commercial simulation machines available for robot-assisted surgery. The validity of Virtual Reality (VR) simulation curricula for psychomotor assessment and skill acquisition for the early phase of robotic surgery training has been demonstrated though limited by the high cost of these machines. Live animal and cadavers have been the accepted standard for robotic surgical simulation since it began in the early 2000s. The latest evolution in synthetic organ model training for robotic surgery has been driven by new 3D-printing technology. Progress would enable a transition in robotic surgical education where digital and synthetic organ models could be used in place of live animals and cadaver training to achieve robotic surgery competency [10]. Over the last decade, urology has taken this cutting-edge technology in its stride; flaunting its efficacy in the augmentation of a number of procedural training applications. The number of use cases for this technology is only expected to rise as its virtues are demonstrated, the ease of use and availability of 3D printing units advances, and costs declined [11].

In summary, 3D printing provides technical support for urology to better serve patients and aid teaching, and 3D bioprinting enables the clinical applications of fabricated constructs for the replacement and repair of urologically damaged organs in the future.

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