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Three-dimensional Elastic Augmented Reality for Robot-assisted Laparoscopic Prostatectomy: Pushing the Boundaries, but Cutting it Fine

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Robotic prostatectomy has been with us now for just on two decades, and in that time urologists have seen this technology move through several iterations and refinements. In addition, robotic surgery, when available, has become the preferred technique for radical prostatectomy and partial nephrectomy. In the case of radical prostatectomy, the advantages of the robotic platform, from ergonomics, to visualisation and the size and dexterity of the instruments, were immediately apparent and desired by urologists chasing the often elusive surgical trifecta of cancer control, continence, and potency preservation [1,2]. However, despite perceptions, technology does not always trump old-fashioned open surgery [3], and experienced surgeons will achieve equivalent outcomes with open and robotic techniques. Nonetheless, technology and the very nature of surgery are always driving innovation, and in the modern era the pace of technological change is increasing.

Augmented reality and virtual-reality applications are well established in the computing and gaming world, and are now entering the surgical mainstream too [4–6]. In this issue of *European Urology*, Francesco Porpiglia and colleagues [7] demonstrate their leadership in this field by showcasing their latest refinement to their hyperaccuracy three-dimensional (HA3D) system for visualising tumour location intraoperatively during robotic prostatectomy. Their platform has arisen out of a synergy between surgeons and engineers, with better patient outcomes as the prime goal. The authors are to be congratulated on bringing this

technology to its current state, as no doubt they faced significant challenges in doing so. In short, Porpiglia and his team have developed a technique to overlay a 3D software model of the patient's prostate, including the location of the tumour fused from magnetic resonance imaging (MRI) results, over the endoscopic view from the robotic camera and project this in the TilePro platform on the Da Vinci robot. The model allows the surgeon to visualise the apparent position of the tumour and relate it directly to the anatomy of the prostate (thereby hopefully avoiding inadvertent positive surgical margins) and to have more confidence in tailoring and adjusting the nerve-sparing technique according to the tumour location and proximity to the prostatic capsule.

While impressive at first glance, and certainly a significant breakthrough that will lead to further developments, the technology is not ready for prime time, and surgeons around the world will have to wait (hopefully not too long) until something like this is available in their own console. First, the authors acknowledge that creating the model is time-intensive, taking 4–6 h per patient, and depends on the engineer's skill set to merge the MR images and create the 3D mesh and import it into the console software. Second, the projected model has to be manually rotated and twisted by an assistant in theatre, who has to watch the surgery on a monitor and continually adjust the model orientation on the screen to match that of the prostate as it is handled and dissected by the surgeon. No doubt this may be distracting for the surgeon at times and

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will slow down the operative flow and add a second line of communication, in addition to that between the surgeon and the bedside assistant. We assume that the authors have plans to create an “autonomous” model that will be software-controlled and moved to match the position of the prostate rapidly and perhaps more accurately. Hopefully future haptic feedback technology will allow the model to adjust for tension forces exerted by the retraction of the prostate by surgical instruments.

The authors have devised a simple experiment to test their technology that involves placing a 5-mm surgical clip at the presumed site of tumour abutment to the prostatic capsule (or CI, “capsular invasion”). They report on a small series of 40 patients, with 20 patients in the HA3D group and 20 in a traditional 2D cognitive group for which the surgeon is required to visualise the position of the tumour using cognitive registration by referencing the MR images and placing the clip at a landmark on the prostate surface visible to the surgeon. All patients in both groups were operated on by the same surgeon (F. Porpiglia). The results show that at a microscopic level the clip placement was perfect in the HA3D group (22/22 lesions) and very good in the 2D group (20/23 lesions; $p = 0.24$). The clip was placed at the site of suspicious capsular bulging in 22/22 cases in the 3D group and 18/23 in the 2D group ($p = 0.06$), with similar results at microscopic assessment ($p = 0.37$). The rate of partial nerve-sparing was 17/20 in the 3D group compared to only 7/20 in the 2D group. This suggests that the surgeon may have been emboldened by having the 3D model available in the first group. However, interestingly, this increase in nerve-sparing technique was not associated with an increase in positive surgical margins ($p = 0.73$), perhaps because of real-time incremental resection of neurovascular tissue around the site of tumour using the intraoperative HA3D technology. However, despite a cohort with predominantly D’Amico low and intermediate risk, there was a high proportion of pT3 disease on final pathology (80% and 75% of cases), which may account for the positive margin rate of 25% and 35% in the HA3D and 2D cognitive groups, respectively.

In summary, the authors have presented a compelling technological advance that may lead to a future built-in software feature on robotic platforms allowing more

confidence in nerve-sparing approaches and the potential to decrease positive surgical margins. However, the early results presented here do not show a significant difference in outcomes, which may in large part be due to a single expert surgeon well past the learning curve being the evaluator. In addition, the small sample size and relatively mismatched nonrandomised patient groups in terms of tumour location, prostate volume, and degree of nerve-sparing performed may have influenced the outcomes. It may be that this technology will be a greater help to less experienced robotic surgeons and those still on the learning curve. We await further developments from this group and others in pushing this exciting innovation.

Conflicts of interest: The authors have nothing to disclose.

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