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Opinion

The Underutilization of 3D Printing in Orthopaedics

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Abstract

3D printing has several clinical applications notably perioperative planning yet is currently underutilized in orthopaedics and more broadly in surgery. This underutilization can be understood in terms of cost, technical familiarity with this technology, and concerns with efficacy. Advances in hardware and open-source software has made 3D printing lower-cost and increasingly accessible, general steps for translating DICOM imaging to tangible 3D prints and guidelines for clinical appropriateness have been published by Radiology Society of North America 3D Printing Special Interest Group, and current literature supports improved surgical outcomes as measured by reduced time spent intraoperatively and improved surgical accuracy.

Keywords: 3D printing; Surgery; Orthopaedics; Efficacy; Education; FFF; SLA; Guidelines

Abbreviations: 3D: three-dimensional; FFF: fused filament fabrication; PLA: polylactic acid RSNA: Radiology Society of North America; SLA: stereolithography; UCSF: University of California San Francisco

Opinion

Medical 3D printing is a burgeoning field of research that aims to improve patient care and outcomes through improved preoperative and intraoperative surgical planning. Surgeons are assisted in their care of patients and in teaching of trainees with patient-specific anatomical models, and individualized prosthetics and matched implants are now available to our patients [1–3]. 3D printing can also be applied towards creating low-cost and robust single-use surgical equipment that can withstand the sterilization process [4,5]. With this broad application space, we think the area of current underutilization, yet greatest benefit is in the area of precision anatomic models for education, training, and pre-surgical planning. When compared with digital models seen on a computer, we believe that tangible 3D prints can improve surgical planning, with better implant selection and fitting, which can reduce intraoperative time [6]. In addition to routine surgeries, 3D models can have even greater utility when applied to high complexity cases [3]. 3D prints can also improve lesion visualization for the surgical team beyond the surgeon, as well as improve patient education by allowing them to visualize their own anatomy [7,8]. Therefore, equipping hospitals and clinics with 3D printing labs that can produce clinically relevant 3D models for use in the operating room is a potentially high-yield low-cost intervention in improving surgical outcomes, as 3D printed patient anatomical models have been shown to reduce operating room time [9]. Previously, there has been resistance to incorporating widespread 3D printing because of cost and time limitations. Advances in hardware and open-source software have mitigated much of these concerns.

Despite these current applications, 3D printing is underutilized in orthopaedics and more broadly in surgery, with this technology only present in select academic centers around the country. Underutilization may be addressed in terms of cost, technical familiarity with this technology, and concerns with efficacy. With 3D printing technology becoming lower-cost and increasingly accessible, as is the case with desktop fused filament fabrication (FFF) and stereolithography (SLA) 3D printers, its incorporation into routine clinical practice in the near future is likely. Generally, the price of preassembled desktop FFF or SLA 3D printers are between $1000 and $3500 USD, with generic polylactic acid (PLA), a 3D printing material used for FFF, priced around $20 USD/kg.[10] In regards to technical familiarity with 3D printing, the Radiology Society of North America (RSNA) 3D Printing Special Interest Group outlines general steps for translating DICOM images into tangible 3D prints and has published guidelines for clinical appropriateness of 3D printing [11,12]. At University of California San Francisco (UCSF), 3D printing resources are available to the community, with no cost to use our FFF printers.

Another possible method of disseminating 3D printing knowledge could be to integrate medical image segmentation and 3D printing training into preclinical education for medical students, which would additionally increase the exposure of 3D printing to the medical team and increase research into medical applications of 3D printing. On the latter point, systematic review of literature reveals that utilizing 3D prints for surgery is clinically effective as determined by reduced time spent intraoperatively and improved surgical accuracy, with most literature investigating the fields of orthopaedic and maxillofacial surgery [13]. However, additional research is needed to investigate the efficacy in other fields of medicine [13]. Here at UCSF, we already have electives on image segmentation for all our health professional schools, utilizing open-source software.

All in all, 3D printing can be a low-cost intervention with research-supported clinical efficacy and guidelines for appropriate clinical use. Increased awareness around medical applications of 3D printing will likely facilitate adoption by physicians into routine clinical practice, as well as increase 3D printing research in other fields of medicine. Medical students may serve as a vehicle of education dissemination, where students are now able to utilize the software and hardware for creating precision anatomic models. In conclusion, medical 3D printing has shown exceptional promise in improving patient care and outcomes, by improving patient understanding, by reducing operating time, and improving surgical accuracy. More 3D printers exist in grade schools and community libraries than at hospitals, which again suggests that we as a medical community are underutilizing this technology for our patients.

Acknowledgement

None.

Conflict of Interest

Dr. Dang – Stock options: Printer prezz.

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