LETTER TO THE EDITOR

Revolution of Plastic Surgery by Innovation in 3D Printing

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Dear Editor,

3D printing is a manufacturing process that creates three-dimensional objects by layering materials based on a digital model. It is revolutionizing plastic surgery by enabling surgeons to tailor their approaches to individual patients, fostering innovation in surgical techniques, planning, and refinement. This manufacturing method proves valuable across surgical planning, medical education, patient communication, tissue engineering, and device prototyping, impacting various aspects of plastic surgery.

Patient-specific 3D-printed implants can be obtained for various purposes and utilized for reconstruction, fulfilling one of the goals of restoring physical integrity in terms of aesthetics. Zhang *et al*. [1] used 3D printing in 3 modes-namely, 3-dimensional printing for manufacturing contour models, guides, and implants in craniofacial plastic surgery for the correction of congenital malformations, the repair of trauma, and cosmetic surgery. The study showed improved aesthetic appearance, which validates the use of this technology by patients.

The 3D printing technique is being used in tissue engineering. A 2023 study by Bülow *et al*. [2] highlights the integration of 3D bioprinting techniques to enhance tissue regeneration by using satellite cells and mesenchymal stem cells to replicate skeletal muscle. The 3D bioprinting technique helps in the creation of complex tissue constructs with high precision and reproducibility. However, one of the challenges is the choice of biomaterial, which should match the biochemical and mechanical properties of the extracellular matrix of the native tissue.

Rare procedures with limited learning opportunities pose a challenge to surgeons in the field of plastic surgery. The recent advances including 3D printing, resolved the issue to a greater extent. For instance, nasal osteotomy in rhinoplasty is challenging to perform; therefore, Schlegel *et al*. [3] designed an updated nasal osteotomy training model, which is user-centred, printable, and cost-effective, by comparing 5 different materials. SimuBone was the material of choice in comparison to human bone, which was chosen subjectively by physicians [3].

Simulators can be developed for surgeries in areas where it is challenging to learn and teach due to visualisation constraints alveolar bone graft surgery is one of them. Shen *et al*. [4] developed the first alveolar bone graft simulator, using three-dimensional printing, polymer, and adhesive techniques. The simulator allows performing a cleft Alveolar Bone Graft surgery, from creating soft tissue flaps to suturing and provides feedback regarding adequate tissue release of the muco-gingivo-periosteal flap to successfully advance and inset the flap for anterior wall closure of the cleft site.

In free flap surgeries, localization of the perforator is an important part of the preoperative planning and requires expertise. In a study, Wei *et al*. [5] compared traditional perforator localization methods with 3D-printed perforator navigator in free fibular flap planning, the latter proved to be more accurate in perforator localization and overall flap success. Moreover, it reduces operation time and minimizes vessel injury by improving accuracy in perforator positioning and mapping of the perforator course. However, more research is warranted in this area, including a randomized controlled study to better demonstrate the clinical value of perforator navigators.

Edema after cosmetic surgeries produces swelling and can temporarily obscure the results; for example, nasal edema after rhinoplasty can occur, leading to distress. Patel *et al* [6] compared traditional postoperative tapping with 3D printed splints and concluded that splints made using 3D printing reduced edema significantly. The ease of use of the 3D splint is one of the reasons for the significant reduction of edema compared with nasal taping which requires untapping and re-taping the nose each day.

There is a significant literature gap in various areas of 3D printing, such as the investigation of improved biocompatible materials with the necessary mechanical properties to withstand physiological environments. Focused research can improve patient-specific implants and prosthetics in complex reconstructions and the accuracy of simulation models to enhance precision in plastic surgery. Research plays a vital role in the

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evaluation of the cost-effectiveness of these models, particularly in resource-limited settings. Moreover, 3D printing can be integrated with artificial intelligence, providing new avenues for innovation. Hence, continued research and innovation in technology are essential to utilizing the real benefits of 3D printing.

Personalized implants, tissue engineering, surgical planning and simulation, scaffolds for tissue regeneration, training tools, and enhancement of aesthetics are the emerging applications of 3D printing. Moreover, the precision and adaptability of 3D printing contribute to improved surgical outcomes and patient care. Utilizing 3D printing can serve as a crucial resource in a surgeon's intellectual and digital toolkit, bridging the gap between concept and reality.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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