

The Current Role of Three-Dimensional Printing in Plastic Surgery

Parisa Kamali, M.D.

David Dean, Ph.D.

Roman Skoracki, M.D.

Pieter G. L. Koolen, M.D.

Marek A. Paul, M.D.

Ahmed M. S. Ibrahim,

M.D., Ph.D.

Samuel J. Lin, M.D., M.B.A.

Boston, Mass.; and Columbus, Ohio



Summary: Since the advent of three-dimensional printing in the 1980s, it has become possible to produce physical objects from digital files and create three-dimensional objects by adding one layer at a time following a predetermined pattern. Because of the continued development of inexpensive and easy-to-use three-dimensional printers and bioprinting, this technique has gained more momentum over time, especially in the field of medicine. This article reviews the current and possible future application of three-dimensional printing technology within the field of plastic and reconstructive surgery. (*Plast. Reconstr. Surg.* 137: 1045, 2016.)

With the advent of three-dimensional printing by Charles W. Hull in the early 1980s, it became possible to produce physical objects from digital files.¹ This technique is now one of many three-dimensional printing modalities referred to as additive manufacturing. Additive manufacturing, or three-dimensional printing, is a fast-growing manufacturing technique where three-dimensional objects are created by adding material one layer at a time in a predetermined pattern.²⁻⁷

Initially, additive manufacturing was focused primarily on producing product prototypes for the automotive and aerospace industries, but it has recently become readily available and inexpensive enough to be used by the general public.^{2,4,7} Currently, the cost of a three-dimensional printer for domestic use ranges from \$300 to \$2500.^{8,9} Because of its ability to produce customized geometrically complex objects in small quantities, often with cost savings because of reduced material use or potential operating room/hospital time savings, additive manufacturing has also led to patient-specific applications in medicine.

Medical additive manufacturing is defined as “the manufacture of dimensionally accurate physical models of human anatomy derived from medical image data using a variety of additive manufacturing technologies.”¹⁰ In the past decade,

medical additive manufacturing has been applied to a range of medical specialties.^{2,4,6,8,9,11-13} Also, various

Disclosure: Dr. Dean has a research collaboration agreement with EnvisionTEC, Inc. (Dearborn, Mich.), a 3D printer manufacturer whose devices are used in this project. He is also the lead inventor of patents assigned to, has received compensation from, and has an ownership stake in Osteoplastics, LLC (Shaker Heights, Ohio). The technology covered by some of those assigned patents is used in this study. Some of the implant design and fabrication technology discussed in this review has been patented and assigned or licensed to Osteoplastics, LLC, and 3DServicePros, LLC (Pepper Pike, Ohio). Dr. Dean has an ownership stake in both Osteoplastics, LLC, and 3DServicePros, LLC. There was no internal or external financial support for this study. None of the other authors has a financial interest in any of the products or devices mentioned in this article.

Supplemental digital content is available for this article. Direct URL citations appear in the text; simply type the URL address into any Web browser to access this content. Clickable links to the material are provided in the HTML text of this article on the *Journal's* Web site (www.PRSJournal.com).

A “Hot Topic Video” by Editor-in-Chief Rod J. Rohrich, M.D., accompanies this article. Go to PRSJJournal.com and click on “Plastic Surgery Hot Topics” in the “Videos” tab to watch.” On the iPad, tap on the Hot Topics icon.

From the Division of Plastic Surgery, Beth Israel Deaconess Medical Center, Harvard Medical School; and the Department of Plastic Surgery, Wexner Medical Center, The Ohio State University.

Received for publication June 21, 2015; accepted November 5, 2015.

Copyright © 2016 by the American Society of Plastic Surgeons

DOI: 10.1097/01.prs.0000479977.37428.8e