Case Reports in Interventional Cardiology

Rapid and Affordable 3-Dimensional Prototyping for Left Atrial Appendage Closure Planning

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An 82-year-old male with the past medical history of right-sided cerebrovascular accident with mild residual deficits, paroxysmal atrial fibrillation, and recurrent gastrointestinal bleeds while on oral anticoagulation was referred for transcatheter left atrial appendage (LAA) closure using the commercially available Watchman closure device (Boston Scientific, Natick, MA).

Prescreening transesophageal echocardiogram images were obtained to assess the LAA size and morphology. The initial transesophageal echocardiogram images revealed a cauliflower configuration of the LAA with an os measurement of 18 mm (Figure 1A through 1C). A proximal posteriorly directed pocket was noted on imaging. Given that this pocket could act as the landing zone for the device, it may lead to inadequate depth and inadequate LAA coverage.

Additional images of the LAA were obtained using multidetector computer tomography, gated to atrial diastole. The 3-dimensional (3D) segmentation of the appendage was performed using the Intuition software (TeraRecon, Foster City, CA; Figure 2A), with additional image processing and smoothing done using publicly available freewares (Meshmixer v3.0; Autodesk Research, Toronto, ON; and Blender v2.76; Blender Foundation, Amsterdam, The Netherlands; Figure 2B). The final stereolithography file was then used for a 3D print model (Figure 2C) of the LAA using white plastic material by Sculpteo (Villejuif, France)—an online consumer 3D printing service—for a nominal fee ($50) with a rapid turnaround (5 days).

The 3D LAA replica was then tested with different Watchman device sizes to assess appropriate position, sizing, and seal (Figure 2D). A 24-mm Watchman device seemed to be the ideal fit for the LAA shape and morphology, with the proximal pocket as the landing zone, although adequate depth was provided to accommodate the device deployment.

We proceeded with transcatheter closure of the LAA using a 24-mm Watchman device using a trans-septal approach. The device landed within the proximal pocket (Figure 1D through 1F), providing adequate seal of the appendage and acceptable compression of the device. Follow-up 45-day transesophageal echocardiogram images revealed stable position and persistent seal with no peridevice leak (Figure 2F). Additional multidetector computer tomography imaging at 45 days demonstrate the position of the device within the LAA as predicted by the in vitro 3D multidetector computer tomography analysis (Figure 2E).

LAA morphology is categorized into 4 variants,[1] and certain morphologies (eg, chicken wing and cauliflower) can prove challenging with transcatheter closure using the Watchman device. Preprocedural planning using 3D reconstruction and printing has been demonstrated in the past[2]; however, they are limited because of high cost for both the software and the 3D print. Although white plastic material is not as malleable as rubber-like materials or flexible plastic, it proved effective for LAA closure planning in our experience.

LAA is less sensitive to motion artifact—due to its larger size—than the coronary arteries. Adequate multidetector computer tomography images can be obtained for the segmentation in patients with persistent or permanent atrial fibrillation if adequate heart rate control is achieved (rate <100 bpm).

The 3D printing medical applications are rapidly expanding, particularly in structural heart intervention preprocedural planning. Cost has been an impediment for wider availability and usage of this technology, however. Its use for percutaneous LAA closure with challenging anatomy (eg, chicken wing) or borderline device sizing may help reduce procedure cost and time. Cost-effectiveness analysis for the routine use of 3D printing for LAA closure guidance needs to be further studied. In this report, we demonstrated a low-cost option for rapid prototyping and manufacturing of LAA for preprocedural planning of LAA closure.

Disclosures

Dr Almany received research/research grants from Boston Scientific Watchman. Dr Hanzel served on the Watchman Scientific Advisory Board for Boston Scientific and is proctor for the Watchman device. All honoraria are paid to Beaumont Health System. The other authors report no conflicts.

References

1. Di Biase L, Santangeli P, Anselmino M, Mohanty P, Salvetti I, Gili S, Horton R, Sanchez JE, Bai R, Mohanty S, Pump A, Cereceda Brantes M, Gallinghouse GJ, Burkhardt JD, Cesarani F, Scaglione M, Natale

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A, Gaita F. Does the left atrial appendage morphology correlate with the risk of stroke in patients with atrial fibrillation? Results from a multicenter study. *J Am Coll Cardiol*. 2012;60:531–538. doi: 10.1016/j.jacc.2012.04.032.

2. Otton JM, Spina R, Sulas R, Subbiah RN, Jacobs N, Muller DW, Gunalingam B. Left atrial appendage closure guided by personalized 3D-printed cardiac reconstruction. *JACC Cardiovasc Interv*. 2015;8:1004–1006. doi: 10.1016/j.jcin.2015.03.015.

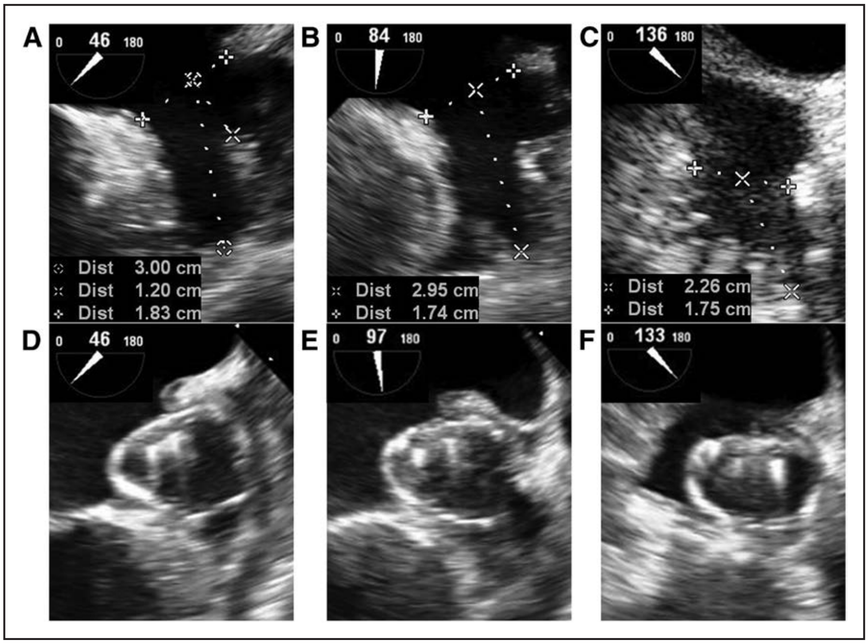

Figure 1. Ostial and depth measurements of the left atrial appendage on preprocedural transesophageal echocardiogram (TEE; **A**–**C**). Corresponding post-Watchman implant TEE images with the device occupying the posterior pocket (**D**–**F**).

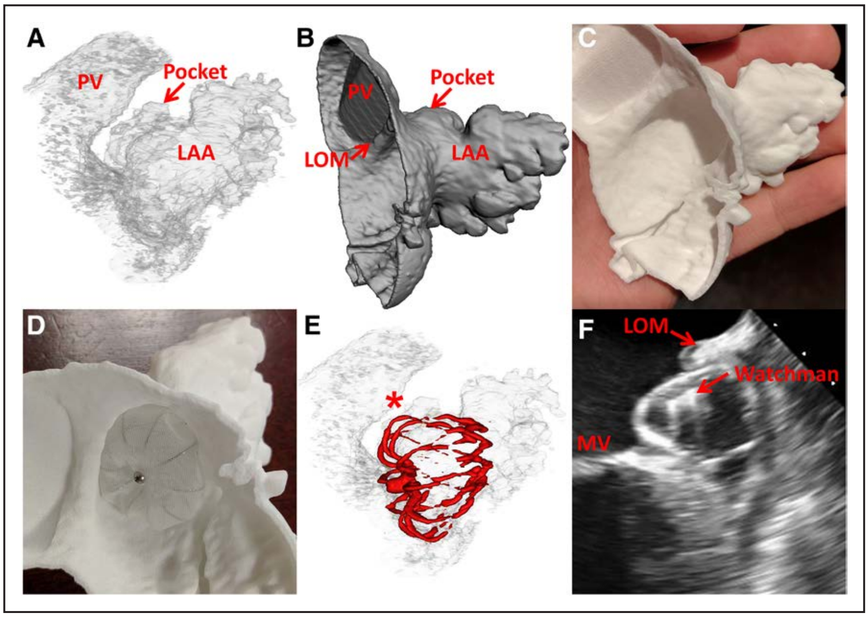

Figure 2. The left atrial appendage (LAA) was segmented (**A**) using the Intuition software with additional processing and smoothing performed using Meshmixer and Blender freewares (**B**). The stereolithography file was submitted for printing by Sculpteo (**C**), an online consumer printing service, and multiple Watchman device sizes were tested in the printed model for the best fit (**D**). Postprocedural multidetector computer tomography and transesophageal echocardiogram images confirm position of the device as predicted by in vitro testing (**E**, **F**). LOM indicates ligament of marshal; MV, mitral valve; and PV, pulmonary vein.

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