Table 1
Patient characteristics.

	Study subjects (n = 30)
Age (years)	64 ± 8
Gender (male/female)	16/14
Duration of AF (month)	24 (12–69)
Hypertension	18 (60)
Diabetes mellitus	3 (10)
Heart failure	1 (3)
Stroke	1 (3)
Left atrial diameter (mm)	38 ± 5
Left ventricular ejection fraction	68 ± 6

The values are expressed as the mean ± SD, median and interquartile range, or n (%). AF = atrial fibrillation.

2.2. Computed tomography imaging and image segmentation

One day before the procedure, multidetector helical computed tomography (CT) (64-channel Somatom-Definition; Siemens-Medical Solutions, Forchheim, Germany) was performed. All patients demonstrated sinus rhythm (SR) at the time of the CT imaging. During the end-expiratory phase, volume image acquisitions were gated at the P wave of ECG lead II. Segmented images of the LA with all pulmonary veins (PVs) derived from chamber volume data were used to reconstruct the structures by means of a 3-step process described previously [3,4].

2.3. Cardiac catheterization

The electrophysiological procedure was performed while patients were in the fasting state. With patients under local anesthesia, a 10 Fr SoundStar ultrasound catheter (Biosense Webster, Diamond Bar, CA) was inserted into the right atrium via the right femoral vein, and anatomic mapping of the LA by the CartoSound module equipped in a CARTO3 system (Biosense Webster) was performed. After the transseptal puncture was performed, 5000 units of heparin was injected into the LA, followed by repetitive injections of 1000 to 2000 units of heparin to maintain an activated clotting time ≥300 s during the procedure. All procedures were performed by 1 operator (N.A.), who had performed over 1000 PV isolation procedures. Two 8.5 Fr long sheaths (Swartz SL1, St. Jude Medical, St. Paul, MN) were inserted into the LA, and no steerable sheath was used in this study.

2.4. 3D-CT merge process

Intracardiac echocardiography (ICE) images were displayed through the CartoSound module using an Acuson X300PE echocardiography system (Siemens Medical Solutions USA, Mountain View, CA). ICE plane images were obtained at the end-tidal position (ACCURESP, Biosense Webster) and 50% of the R-R interval as described previously [5]. The range of the contours sampled was 6 to 9 between the ostia of the right PV and left PV, and these contours were registered as the LA ICE image. After visual alignment, the 2 images were integrated with the installed surface registration program [6].

2.5. Creation of a conventional fast-electroanatomical-mapping (FAM) and high-CF guided FAM

After the 3D-CT merge process, 3D geometries of the LA and PVs were created with an FAM algorithm [7,8]. In brief, high-resolution 3D chamber volumes were created from continuous recordings of the multipolar catheter movements within the cardiac chambers to outline the structures. All geometries were created during SR, and the 3D geometries were automatically gated to the respirations (ACCURESP), and the FAM and mapping points for the analysis were acquired during the expiration phase. Regarding the creation of the conventional-FAM, the ablation catheter was only used for verification of each PV location, and a 20-pole multielectrode steerable mapping catheter arranged with 5 soft radiating splines covering a diameter of 3.5 cm (Pentaray, Biosense Webster) was used for the LA geometry. A typical example of a conventional-FAM geometry is demonstrated in Fig. 1 (left panel).

In order to characterize the regional distortion area of the LA, point-by-point mapping with a high (>10 g) contact force at each PV antrum and the LA body surface were created (high-CF guided FAM) after the creation of the conventional FAM. The operators tried to keep a certain level of high contact (10–50 g) at each mapping point. No radiofrequency applications were delivered during the creation of high-CF guided FAM. A typical example of a conventional-FAM geometry is demonstrated in Fig. 1 (right panel). Systematic high-CF guided PV antrum maps in each of the 8 segments of the left and right PVs were created (Fig. 2A).

The LA shell was also divided into 6 distinct anatomic segments [9]: septum, anterior wall, floor, lateral wall, posterior wall, and roof in that order (Fig. 3A). High-CF guided points were systematically obtained with at least 2 points in each segmented PV antral region, and at least 3 points (>5 mm separation from each other) in each LA region.

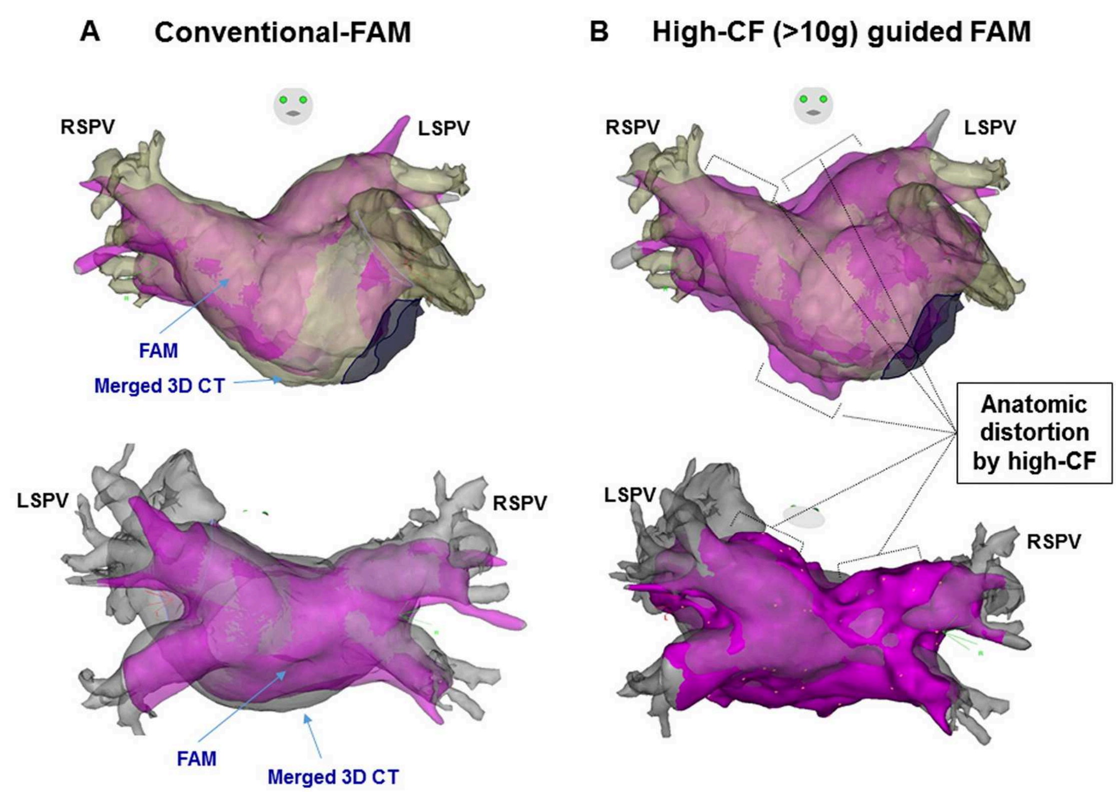

Fig. 1. A: Typical example of merged 3D US-CT-derived and conventional FAM-derived geometries. B: Typical example of merged 3D US-CT-derived and high contact force (>10 g) guided FAM-derived geometries. A large difference in the distance from the 3D US-derived rendering was noted between the conventional FAM-derived rendering and high contact force (>10 g) guided FAM-derived rendering at the roof of both the right and left PV antra, roof, septum, and floor of the left atrial body region. FAM, fast anatomical mapping; vein; LSPV, left superior pulmonary vein, RSPV, right superior pulmonary vein.