**Introduction**: We previously reported the additional benefit of a superior vena cava to right atrial septum linear ablation (SVC-L) after circumferential pulmonary vein isolation (CPVI) in patients with paroxysmal atrial fibrillation (AF) within a year. We explored the long-term effects of the SVC-L as well as its potential related mechanisms.

**Methods**: Among 2,140 consecutive patients with AF ablation, we included 614 patients (73.3% male, 57.8±10.7 years old, 13.7% persistent AF) who did not undergo an extra-PV left atrial (LA) ablation after propensity score matching: 307 additional SVC-L group vs. 307 CPVI alone group patients. We evaluated the heart rate variability (HRV) and computational modeling study to explore the mechanisms.

**Result**: Although the procedure time was longer in the SVC-L group than CPVI group (P<0.001), the complication rate did not differ between the two groups (p=0.560). During 40.5±24.4 months of follow-up, the rhythm outcome was significantly better in the SVC-L group than CPVI group (Log-rank p<0.001). At the 2-year follow-up of the HRV, a significantly higher mean heart rate (p=0.018) and lower LF/HF ratio (p=0.011) were found in the SVC-L group than CPVI alone group. In realistic in silico bi-atrial modeling, which reflected the electro-anatomies of 10 patients, the SVC-L significantly reduced the biatrial dominant frequency compared to the CPVI alone (p<0.001), and increased the AF termination and defragmentation rates (p=0.033).

**Conclusion**: An SVC-L ablation in addition to the CPVI significantly improved the over 2-year long-term rhythm outcome after AF catheter ablation by mechanisms involving autonomic modulation and AF organization.