

## ORIGINAL RESEARCH

# Incremental Efficacy for Repeat Ablation Procedures for Catheter Ablation of Atrial Fibrillation

## 5-Year Follow-Up

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## ABSTRACT

**BACKGROUND** Catheter ablation atrial fibrillation (AF) is effective, but 20% to 40% of patients will require a repeat ablation. The role of more than 1 repeat ablation is not well known.

**OBJECTIVES** The purpose of this study was to evaluate the effectiveness and incremental benefits of multiple repeat catheter ablations to treat AF in patients.

**METHODS** We retrospectively included patients who underwent their first, second, third, and fourth AF ablation between 2004 and 2019. They were monitored with a 24-to-48-hour Holter every 3 months postablation the first year and every 6 to 12 months thereafter. Recurrence was defined as documented atrial arrhythmia >30 seconds. Outcomes are analyzed by Kaplan-Meier curves and compared by log rank test.

**RESULTS** We included a total of 2,194 patients (64% with paroxysmal and 36% with nonparoxysmal AF). Mean age was  $71 \pm 10$  years; 67% were male. After 1 ablation, freedom from AF was 52%. Among those 1,052 patients who had recurrences, 576 (55%) underwent a second ablation, 103 (10%) underwent a third procedure, and 20 (2%) underwent a fourth. Success rates for the second, third, and fourth ablation were 57%, 60%, and 40%, respectively, at 5-year follow-up. After the second ablation, freedom from AF in our entire cohort increased from 52% to 66%, with marginal changes after the third (67%) and fourth (67%) procedures.

**CONCLUSIONS** Although repeated ablations demonstrated significant benefits at the individual level, the success rate may drop off after a third. The overall success of the initial cohort was not significantly influenced by the success rates of multiple follow-up ablations. (JACC Adv 2024;3:101200) © 2024 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

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The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the [Author Center](#).

Manuscript received March 22, 2024; revised manuscript received June 21, 2024, accepted June 27, 2024.

**ABBREVIATIONS  
AND ACRONYMS****AF** = atrial fibrillation**CF** = contact force**LA** = left atrium**PV** = pulmonary vein

The current role of catheter ablation to treat atrial fibrillation (AF) is well established and outcomes are widely reported over 1 to 2 years follow-up with few studies providing follow-up data beyond 3 years or more.<sup>1-4</sup>

Although technologies and techniques have improved outcomes over the last several years, recurrence rates after a single catheter ablation remain high (35%-50%), especially for persistent AF.<sup>5,6</sup> Not all patients with isolated recurrences will require a repeat procedure, but about half (15%-30%) of patients with recurrence will require a repeat procedure.<sup>2,7,8</sup>

While 1 repeat ablation is considered clinically useful, the role of more than 1 repeat ablation and its impact on overall ablation success rates over the long-term follow-up is not well known.

The purpose of this study is to report long-term outcomes of 1 or more AF ablations in a large cohort of patients and to determine the effectiveness and incremental benefit of repeat ablations after an initial procedure.

**METHODS**

**PATIENT CHARACTERISTICS.** Patient data were extracted from a database of all AF ablations performed at Southlake Regional Health Centre (Ontario, Canada). The database included information about the ablation procedures, as well as clinical data such as echocardiogram parameters and other imaging data. It was also supplemented by electronic medical records documenting hospitalizations, emergency visits, and other interventions. Since our center is the only AF ablation center in our region of over 1.5 million people, our population is largely limited to follow-up, emergency visits, and/or hospitalization in our network of hospitals.

Consecutive patients with 1 or more AF ablation from 2004 to 2019 and at least 3 months of follow-up were included. A total of 2,194 patients were analyzed. Collection, review, and follow-up of patient data were in accordance with local research ethics board guidelines.

**CATHETER ABLATION.** Antiarrhythmics were stopped at least 5 half-lives, and amiodarone at least 4 weeks before ablation. Procedures were performed under deep sedation or general anesthesia. Radiofrequency was used in 97% of the procedures, and only 3% of the cases were performed with cryoablation. In brief, venous access was obtained for insertion of

diagnostic catheters and the ablation catheter. Left atrial access was via single or double transeptal catheterization. Intracardiac echo was used for all procedures to guide transeptal punctures, identify the pulmonary vein (PV) antrum, and monitor for complications such as pericardial effusion. Patients were anticoagulated with intravenous heparin to maintain an activated coagulation time above 300 to 350 seconds.

After transeptal, a multipolar circular catheter or a penta-spline mapping catheter was positioned in the left atrium (LA). Electroanatomical mapping was used for all cases. From 2004 to 2006, an 8-mm-tip ablation catheter was used, and thereafter, an irrigated tip 3.5-mm catheter was used. After 2010, contact force (CF) sensing catheters were used. With the 8-mm-tip catheter, the target temperature was kept constant at 50 °C, and the power used was 35 to 50 W while monitoring for microbubble formation. With the irrigated tip ablation, 35 to 45 W were used, and when available, target CF was between 5 and 20 g. Esophageal temperature was monitored, and the radiofrequency delivery paused if the esophageal temperature increased by 1.5 °C. Acute procedural success was defined as complete loss of potentials within the PV antrum with confirmed entrance and exit blocks.

During the first procedure, after performing PV isolation, the decision to isolate the posterior wall was left to the discretion of the operator. However, for repeat procedures, all patients underwent both PV isolation and posterior wall isolation. Additionally, in some cases during repeat procedures, non-PV triggers were sought after administering high doses of isoproterenol infusion.

**FOLLOW-UP AND ENDPOINTS.** All patients underwent monitoring with a 24- to 48-hour Holter every 3 months during the first year after each ablation (3-6-12-month follow-up) with subsequent follow-ups occurring every 6 to 12 months. Patients experiencing symptoms were provided with additional Holter or extended external loop recorders. Recurrence of AF was defined as the presence of documented atrial arrhythmia lasting longer than 30 seconds following an initial 3-month blanking period. AF recurrences were identified through analysis of the Holter monitor, loop recorder data, electrocardiogram assessments in outpatient clinics, emergency departments, or hospitalizations. No blanking period was used for AF recurrences after repeat ablation procedures.

The primary endpoint of the study was efficacy, defined as freedom from atrial arrhythmia at the 5-year follow-up. Secondary endpoints included complication rates, PV reconnections, and predictors of recurrences for repeat catheter ablations.

**STATISTICAL ANALYSIS.** Continuous data are reported as mean ± SD, and comparisons between groups were performed using the student t test. Categorical variables are presented as frequency (percentage) and were compared using the chi-square test or Fisher exact method. Multivariable Cox regression was used to identify significant predictors of AF recurrence. The OR and 95% CI were computed. Recurrence-free survival over time was calculated by Kaplan-Meier method. Differences between strata were assessed with the log-rank test distributions. For all tests, a P value of <0.05 was considered statistically significant. Analysis was performed using SPSS 17.0 software (IBM).

## RESULTS

**PATIENTS AND FIRST ABLATION PROCEDURE.** A total of 2,194 patients that underwent catheter ablation for AF between 2004 and 2019 were included. From them, 1,411 (64%) had paroxysmal and 783 (36%) had nonparoxysmal AF. From the nonparoxysmal group, 699 patients (32%) had persistent AF and 84 patients (4%) long-standing persistent AF. Medium age was 71 ± 10 years, 67% were male, radiofrequency was used for 97% of procedures, and CF in 50% of the cases. Mean procedural time was 2.6 ± 2.1 hours, mean fluoroscopy time was 46 ± 87 minutes, and mean radiofrequency time was 64 ± 47 minutes. Baseline characteristics are summarized in **Table 1**. The flow of the patients in this study is shown in **Figure 1**.

After 1 AF ablation, freedom from any atrial arrhythmias off antiarrhythmic drugs was 52% during a mean follow-up of 5 years. Patients with paroxysmal AF had higher success rate than those with nonparoxysmal (56% vs 44%; *P* < 0.001) (**Figure 2**).

**INCIDENCE OF REPEAT ABLATION PROCEDURES.** Of the 2,194 patients included, 1,052 patients (48%) had a recurrence. In terms of timing after the initial procedure, 58% of recurrences occurred within the first-year postablation, 20% during the second year, 7% during the third year, 4% after 4 years, and 4% after 5 years (**Figure 3**).

Of these recurrence patients, 576 (55%) underwent a second AF ablation procedure, 103 (10%) underwent a third ablation, and 20 (2%) underwent a fourth (**Figure 1**).

	Single Ablation	Repeat Ablation	P Value
Age, y	70 ± 11	72 ± 10	<b>&lt;0.001</b>
Female	33%	34%	0.58
Hypertension	56%	60%	0.09
Diabetes	12%	11%	0.20
Prior stroke	5%	5%	0.77
Sleep apnea	22%	22%	0.96
Coronary artery disease	13%	14%	0.741
Type AF			
Paroxysmal	66%	58%	
Persistent	31%	35%	<b>&lt;0.001</b>
Long persistent	3%	7%	
Number of failed AAD	1 ± 1	2 ± 1	<b>&lt;0.001</b>
Failed >1 AAD	29%	52%	<b>&lt;0.001</b>
LVEF	54 ± 6	55 ± 6	0.9
LA diameter	41 ± 5	43 ± 6	<b>0.03</b>

Values are mean ± SD or %. The values in **bold** indicate a P value <0.05.  
 AF = atrial fibrillation; AAD = antiarrhythmic drug; LA = left atrium; LVEF = left ventricular ejection fraction.

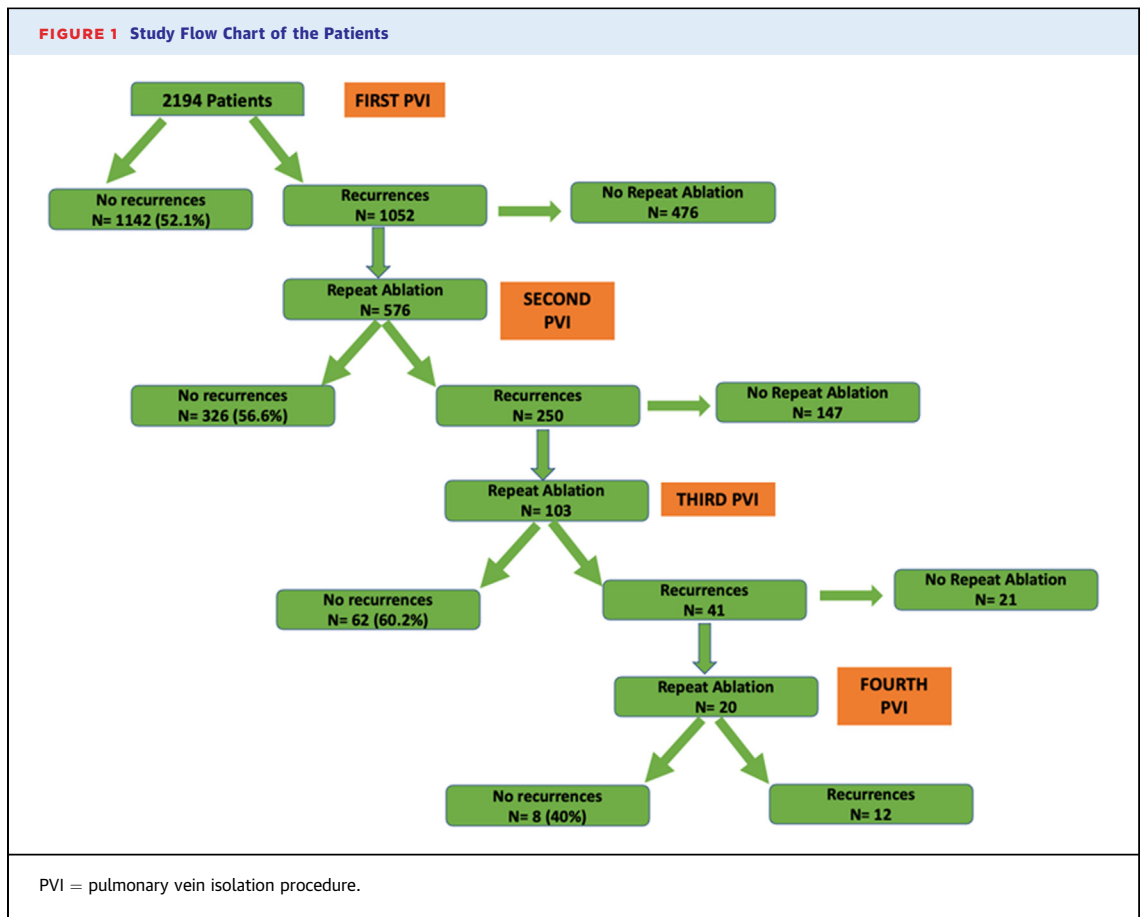
**Table 1** shows differences in baseline characteristics according to whether patients had a single or repeat ablation. Patients who underwent 1 or more repeat ablations were older, were more likely to have persistent and long persistent AF, had bigger LA diameter, and failed more antiarrhythmic drugs than those who underwent a single ablation.

**OUTCOMES OF REPEAT ABLATIONS.** Per-ablation success rates off antiarrhythmic drugs for the second, third, and fourth ablation were 57%, 60%, and 40%, respectively, at 5-year follow-up. There were no differences in success rates in paroxysmal vs nonparoxysmal AF patients for the second (56% vs 57%; *P* = 0.70), third (60% vs 59%; *P* = 0.70), or the fourth ablation (42% vs 38%; *P* = 0.70) (**Table 2**).

The overall success rate of the cohort changed from 52% after 1 procedure to 66% after 1 or 2 procedures. After 1 to 3 ablations, the success rate of the cohort was 67%. After 1 to 4 ablations, the success rate of the cohort was also 67%. **Figure 4** shows the arrhythmia-free survival after 1, 2, 3, and 4 ablation procedures for the entire cohort. **Central Illustration** shows long term outcomes of repeat ablation.

Although after final ablation we showed a trend toward a better outcome or patients with paroxysmal AF, the difference was not significant (70% vs 62% for paroxysmal vs nonparoxysmal AF; log-rank = 0.09) (**Figure 5**).

If we exclude patients who did not undergo repeat ablation by choice because, although they still had atrial arrhythmia per definition, their quality of life



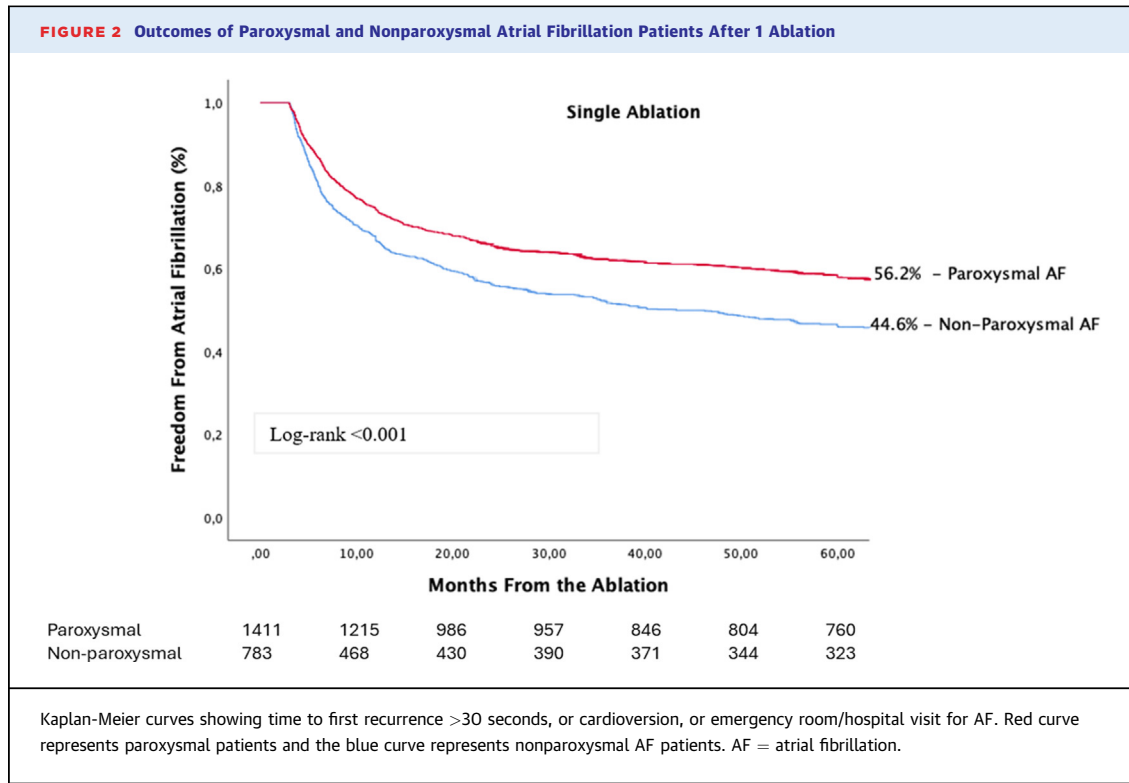
had normalized due to significant decrease in the clinical burden of atrial arrhythmia and limit our analysis to those patients who were either considered successful after a single procedure or underwent repeat ablation for any recurrence until they were successful, then the total success rate over 5 years was 85% (Figure 6).

**OUTCOMES BEFORE AND AFTER THE INTRODUCTION OF CONTACT FORCE SENSING CATHETERS.** From 2,194 patients who underwent AF ablation, 515 patients (23%) were performed before 2010, when CF sensing catheters were not available. From 576 patients who underwent 2 ablations, 147 (26%) were performed without CF catheters. From 103 who underwent 3 ablations, 23 (22%) were performed without CF sensing catheters. And from 20 patients who underwent 4 ablations, 4 patients (8%) were performed without CF catheters. In terms of outcomes, per-ablation success rates at 5-year follow-up before vs after the use of CF sensing catheters were 35% vs 57% ( $P = 0.807$ ) for the first ablation, 35% vs 65%

( $P < 0.001$ ) for the second ablation, 52% vs 63% ( $P = 0.417$ ) for the third ablation, and 0% vs 50% ( $P = 0.009$ ) for the fourth one.

**PREDICTORS OF RECURRENCE AFTER A REPEAT ABLATION.** Table 3 shows univariate Cox regression analysis of predictors of AF recurrences after the first ablation. Older age, nonparoxysmal AF, higher LA diameter, and higher number of antiarrhythmic drugs failed were predictors of AF recurrences after the first ablation. All these variables remained significant in the multivariable analysis as well. For prediction of recurrence after a repeat ablation, however, only the number of antiarrhythmic drug failures was found to be significant (Table 4).

**ELECTROPHYSIOLOGICAL FINDINGS DURING REPEAT ABLATIONS.** A reconnection in at least 1 PV was found in 91% of the patients who underwent a second ablation, in 81% of the patients who underwent a third, and in 71% of the patients who underwent a fourth ablation (Figure 7).

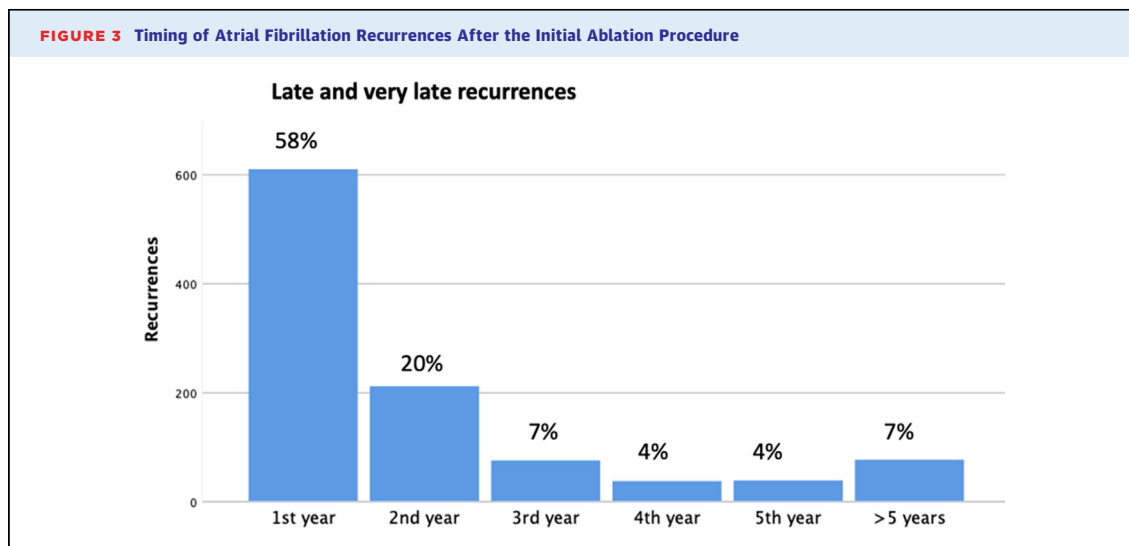


**COMPLICATIONS.** Complications included 12 tamponades (0.5%), 14 (0.6%) thromboembolic events including transient ischemic accident and stroke, 18 vascular complications requiring surgical or percutaneous intervention (0.8%), 1 atrioventricular block (0.05%), and 1 death due to atriopharyngeal fistula (0.05%). Thirty-one patients (1.4%) required

hospitalization for heart failure within the first 30 days postablation.

**DISCUSSION**

In this study, we demonstrate that while more than 50% of recurrences post-AF ablation occur within the



**TABLE 2 Per-Procedure and Cumulative Success Rates Postablation**

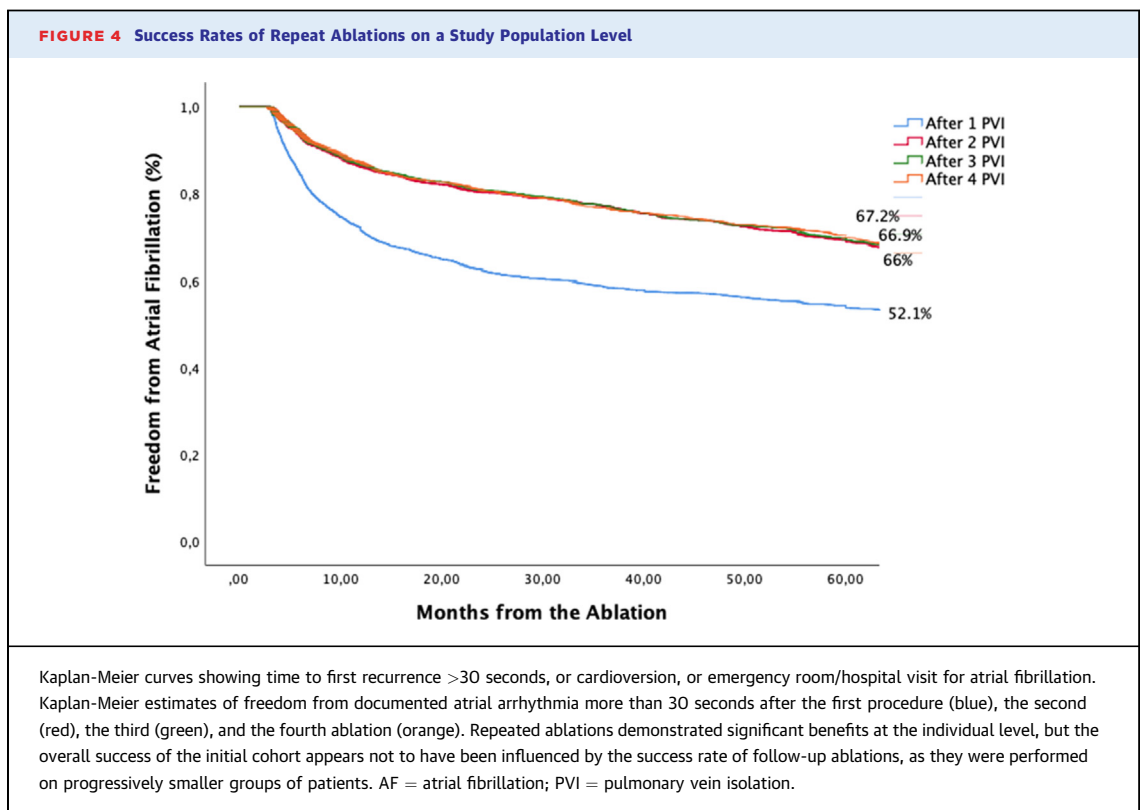
	First Ablation Success (%) (n = 2,194)	Second Ablation Success (%) (n = 576)	Third Ablation Success (%) (n = 103)	Fourth Ablation Success (%) (n = 20)
Paroxysmal AF	56.2%	56.9%	60.4%	41.7%
Persistent and long-standing persistent AF	44.4%	56.6%	59.3%	37.5%
	Freedom From AF After 1 Ablation (n = 2,194)	Freedom From AF After 2 Ablations (n = 2,194)	Freedom From AF After 3 Ablations (n = 2,194)	Freedom From AF After 4 Ablations (n = 2,194)
Paroxysmal AF	56.2%	69.3%	69.8%	70.1%
Persistent and long-standing persistent AF	44.4%	60.4%	61.5%	61.8%

Values are %.  
AF = atrial fibrillation.

first year after ablation, 35% will occur during the second to fifth years postablation. Of these patients with recurrences, about half (55%) had recurrences severe enough to undergo a second AF ablation procedure, 10% underwent a third ablation, and 2% underwent a fourth. The per-procedure success rate for the first, second, and third repeat ablations were similar (57%, 60%, and 60%, respectively) While the success rate after the fourth procedure was only 40%, this is based on a very small sample of 20 patients or roughly 1% of the original cohort. Looking at the overall cohort, freedom from AF after a second

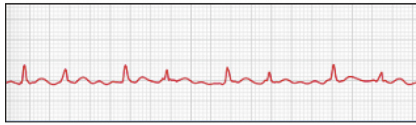
procedure changed overall outcome from 52% to 66%. It seems that, although repeated ablations demonstrated benefits at the individual level, the overall success of the initial cohort was not as much influenced by the success rate of multiple follow-up ablations. PV reconnection remained in most of those undergoing repeat ablation even after multiple procedures. This study is one of only a few to examine the incremental benefit of multiple repeat ablations over long-term follow-up.

Very few studies have reported outcomes for more than 1 repeat ablation and many of these studies were

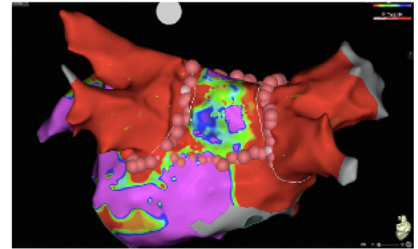
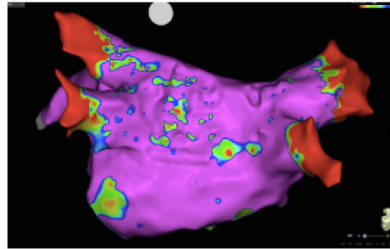


**CENTRAL ILLUSTRATION** Long-Term Outcomes of Repeat Ablation Procedures

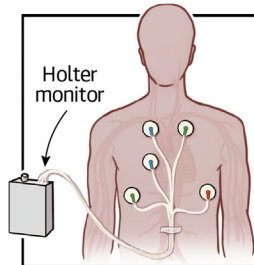
**Atrial Fibrillation Ablation**



2,194 patients with paroxysmal and persistent atrial fibrillation (AF) underwent ablation



**Repeat Ablation**



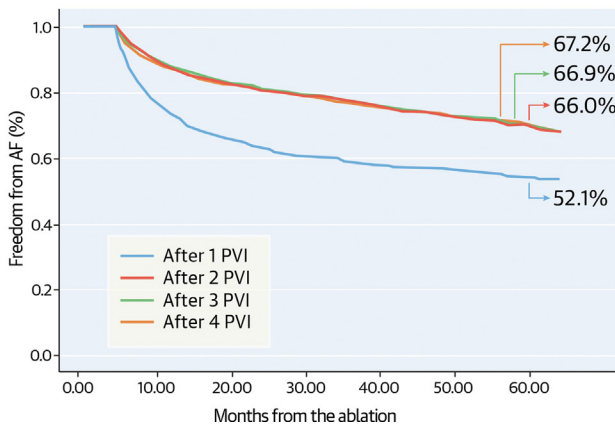
24 to 48 h  
 Holter  
 monitoring

5-YEAR FOLLOW-UP

1,052 patients with  
 AF recurrences:

- 576 underwent a second ablation
- 103 a third ablation
- 20 a fourth ablation

**Outcomes at 5-Year Follow-Up**



**Per-Procedure and Cumulative Success Rates Post-Ablation**

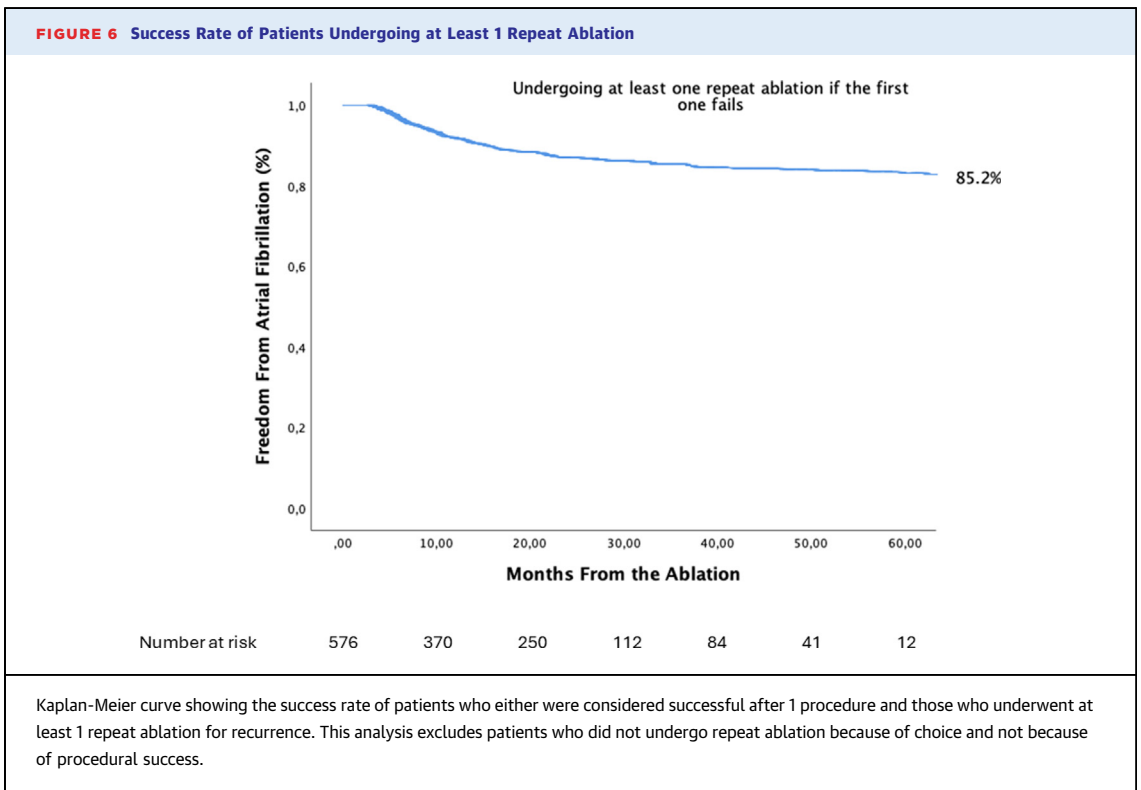
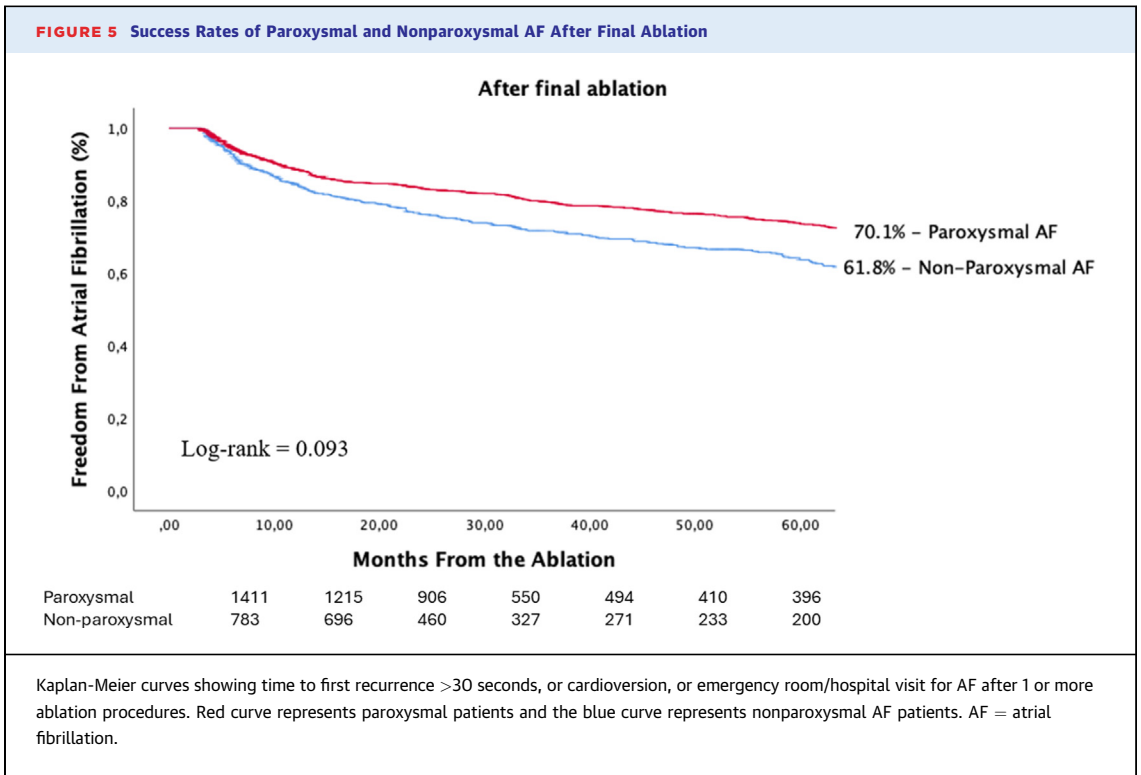
	1st ablation success (%) n=2,194	2nd ablation success (%) n=576	3rd ablation success (%) n=103	4th ablation success (%) n=20
Paroxysmal AF	56.2%	56.9%	60.4%	41.7%
Persistent and long-standing persistent AF	44.4%	56.6%	59.3%	37.5%
	Freedom from AF after 1 ablation n=2,194	Freedom from AF after 2 ablations n=2,194	Freedom from AF after 3 ablations n=2,194	Freedom from AF after 4 ablations n=2,194
Paroxysmal AF	56.2%	69.3%	69.8%	70.1%
Persistent and long-standing persistent AF	44.4%	60.4%	61.5%	61.8%

Sanchez-Somonte P, et al. JACC Adv. 2024;3(9):101200.

AF = atrial fibrillation; PVI = pulmonary vein isolation.

performed long ago, had small sample sizes, and had limited follow-up. Lo et al for example, included 52 patients undergoing 3 ablations and 12 patients undergoing 4, reporting success rates of 62% and 75%, respectively, at 3-year follow-up.<sup>9</sup> The results of Ouyang et al were similar.<sup>10</sup> Their study reported that success postablation increased from 47% after 1 procedure to 79% after multiple procedures; 66 patients

had a second procedure and 12 had a third. The per-procedure success rate of the second procedure was 67% and the third procedure 75%. Other studies have demonstrated poorer results from repeat procedures. Chao et al<sup>11</sup> reported that in nonparoxysmal patients, success after 1 procedure was only 28%, which increased to 51% after multiple procedures, but only a small number underwent 2nd (n = 41) and 3rd (n = 6)





**TABLE 3** Univariable Cox Regression Analysis of Factors Affecting AF Recurrences for the First Ablation

	HR	HR 95%	P Value
Age	1.008	1.001-1.014	<b>0.026</b>
Female	1.151	0.994-1.332	0.060
Nonparoxysmal AF	1.152	1.004-1.320	<b>0.043</b>
Hypertension	0.914	0.796-1.051	0.208
Diabetes	0.876	0.722-1.063	0.180
Sleep apnea	0.939	0.804-1.098	0.433
Coronary artery disease	1.019	0.850-1.098	0.836
Previous stroke	0.771	0.583-1.018	0.067
LVEF	1.002	0.991-1.014	0.709
LAD	1.027	1.014-1.041	<b>&lt;0.001</b>
Number of failed AAD	1.177	1.114-1.244	<b>&lt;0.001</b>

The values in **bold** indicate a P value <0.05.

AAD = antiarrhythmic drugs; AF = atrial fibrillation; LAD = left atrial diameter; LVEF = left ventricular ejection fraction.

**TABLE 4** Univariable Cox Regression Analysis of Factors Affecting AF Recurrences for a Repeat Ablation

	HR	HR 95%	P Value
Age	1.004	0.983-1.025	0.728
Female	1.305	0.865-1.970	0.205
Nonparoxysmal AF	1.244	0.862-1.797	0.244
Hypertension	0.841	0.578-1.224	0.365
Diabetes	0.656	0.332-1.294	0.224
Sleep apnea	1.020	0.665-1.565	0.927
Coronary artery disease	0.885	0.516-1.517	0.658
Previous stroke	1.150	0.555-2.381	0.707
LVEF	1.004	0.972-1.037	0.791
LAD	0.998	0.963-1.035	0.933
Posterior wall performed	1.448	0.987-2.126	0.058
Number of failed AAD	1.246	1.108-1.402	<b>&lt;0.001</b>

AAD = antiarrhythmic drugs; AF = atrial fibrillation; LAD = left atrial diameter; LVEF = left ventricular ejection fraction.

ablations. The success rate of the second procedure was only 41%, and the third had a success rate of only 50%. Weerasooriya et al<sup>12</sup> also reported on a limited number of patients undergoing 2 (n = 51) and 3 (n = 17) patients with a success rate of 39% for the second ablation and 70% for the third. Finally, Miyazaki et al reported on 26 patients with 3 ablations and 3 patients with 4 ablations, and they found that the success rate of repeat ablations dropped off from 85% to 0% after the third and fourth ablations.<sup>13</sup> Given the limited number of repeat ablations reported in these studies, it is difficult to assess the incremental value of more than 1 repeat ablation. Our study included 576 patients undergoing a second procedure and 103 patients undergoing a third, which is more than all these studies combined.

The abovementioned studies were also conducted on patients receiving ablation before CF sensing, open-irrigated tip catheters, while from our total cohort of 2,194 patients, only 23% of them were performed before 2010 when CF sensing catheters were not available.

Given the limitations of older technology, PV reconnections were common and repeat ablations may have offered relatively more incremental benefit. In the era of CF-sensing catheters, however, incremental benefit of repeat ablations may be less. In a trial comparing CF sensing to no CF sensing for ablation of persistent AF,<sup>14</sup> success rate after 1 procedure for the total trial population (n = 128) was 71%. After a second procedure, the success rate increased to only 77%, meaning the success rate of the second procedure was only 33%. In another trial comparing CF ablation to cryoballoon,<sup>15</sup> the success rate of the 3 arms was not different, ranging from 52% to 54%.

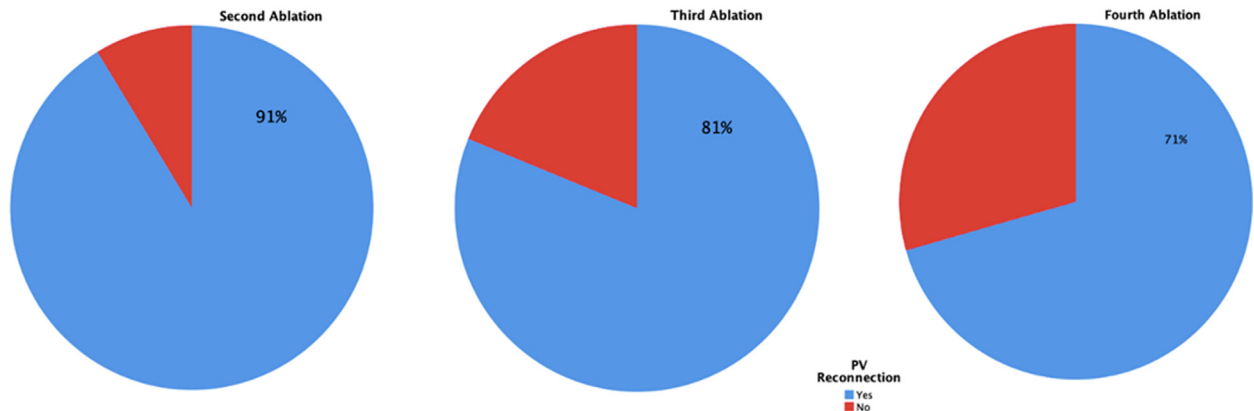
After a second procedure, the success rate increased to 63% to 64% in all 3 arms, meaning the success of a second procedure was only 44% to 61%. These results certainly are less encouraging for second ablations compared to earlier studies. The success rate of second and third ablations in our cohort are more in keeping with Andrade et al but our results may be slightly higher given our inclusion of patients ablated using historical ablation technologies.

It is interesting that even at the third and fourth ablation, PV reconnection was still present. Again, this could be due to the inclusion of patients receiving more antiquated technologies. However, it also shows the challenge of getting truly durable PV isolation. There is probably less PV reconnection with more modern techniques of ablation (CF, cryoballoon, and even pulsed field ablation), but this even makes the benefit of a repeat ablation even less certain since the optimal technique for ablation beyond the PVs is still unknown.

From a health policy perspective, our data should give caution to allowing an unlimited number of repeat ablations for patients. Certainly, there seems to be a benefit to a second procedure on a population level (52% vs 66%), and the success rate of a third procedure remains 60%. However, the incremental benefit of a fourth procedure changes the population outcome for our cohort minimally, and the success rate of the fourth ablation falls to 40%, albeit on a very small number of patients. The lack of a change in the overall population outcome is partially explained by the small number of patients undergoing third and fourth procedures. However, there may also be a diminishing rate of return provided by additional procedures, especially once you reach the

**FIGURE 7** Pulmonary Vein Reconnection Rates After Repeat Ablation Procedures

### Reconnection in at least 1 PV



The blue regions represent the percentage of patients with at least 1 pulmonary vein reconnection and red regions represent the percentage of patients without pulmonary vein reconnection. PV = pulmonary vein.

fourth. Finally, not all patients who have recurrence after a first procedure undergo a repeat ablation. In our study, only 55% of patients with recurrence after the first ablation underwent a second ablation. This may be because the AF burden has been sufficiently reduced after the first ablation that the patient is no longer symptomatic from their arrhythmia.<sup>15</sup> This is consistent with other studies showing that the patient needs to have a certain burden of AF in order to impair their quality of life sufficiently to warrant ablation. Clinical burden of AF in patients who continue to have arrhythmia recurrences following ablation is diminished by as much as 95% in some studies.<sup>15</sup> Other patients may simply not want to undergo a repeat intervention regardless of residual symptoms. In our study, we reported a metric of success that only included patients who underwent a first procedure and then underwent two or more repeats for a failed procedure. This metric excludes all patients with recurrence after a first procedure who do not accept the second procedure, a metric called “going all the way” first reported by Winkle et al.<sup>16</sup> Using this metric, the success rate (or freedom from another ablation) after 2 or more procedures over 5 years is 85%. This is an important metric to inform patients after a failed first procedure of what to expect as an overall success after repeat ablation.

**STUDY LIMITATIONS.** First, this is a retrospective, single-center, nonrandomized study. AF monitoring was performed with 24 to 48 hours Holter at a routine follow-up, but the absence of more routine, intensive monitoring systems could have resulted in AF recurrence underestimation. We did not have any measures of AF burden, so we cannot conclude whether patients’ AF burden was substantially improved after repeat ablations, although other published data suggests this is so.<sup>15</sup> Second, we reported arrhythmia recurrences as any atrial arrhythmia longer than 30 seconds, but we did not consider in the analysis the type of arrhythmia (AF vs atrial flutter vs atrial tachycardia). Third, half of the patients who recurred preferred not to have a repeat ablation at least presumably due to the very low clinical burden of AF in these patients. Fourth, all of the patients in this series received their repeat ablations at the same site as the initial ablation, so our findings may not be relevant to jurisdictions where initial ablations may be performed by community-based centers with repeat ablations occurring in tertiary centers. On the other hand, all the procedures were performed with radiofrequency or cryoablation, so the results cannot be extended to evolving technologies such as pulse field ablation. Finally, these were all patients undergoing repeat left-sided ablation for AF, or complex left atrial flutters. If a patient presents with a nonpulmonary

vein-dependent arrhythmia, such as supraventricular re-entrant tachycardia, right atrial flutter, or ventricular arrhythmia, further ablation procedures may be warranted regardless of the number of left atrial ablations.

## CONCLUSIONS

Repeat catheter ablation for AF are important to maintain sinus rhythm in a wide proportion of patients during long-term follow-up. Although repeated ablations demonstrated significant benefits at the individual level, the success rate may drop off after a third. The overall success of the initial cohort was not significantly influenced by the success rate of multiple follow-up ablations.

## FUNDING SUPPORT AND AUTHOR DISCLOSURES

Dr Sanchez-Somonte was supported by a grant from La Fundación Alfonso Martín Escudero (Madrid, Spain). Dr Khaykin has received research grants from Biosense Webster and Medtronic. Dr Verma has received research grants from Bayer, Biosense Webster, Biotronik,

Medtronic, and Medlumics; has received compensation for advisory boards for TheraMedical, Ablacon, Adagio Medical, Biosense Webster, Boston Scientific, Galaxy Medical, Medtronic, Medlumics, and TheraMedical. All other authors have reported that they have no relationships relevant to the contents of this paper to disclose.

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## PERSPECTIVES

**COMPETENCY IN MEDICAL KNOWLEDGE:** This study describes the incremental impact and potential plateau of repeat AF ablation.

**TRANSLATIONAL OUTLOOK:** Repeat catheter ablation procedures for AF are important to maintain sinus rhythm. However, while repeat ablations benefited individuals, success rates plateaued after the third, minimally affecting the initial cohort's overall success.

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**KEY WORDS** atrial fibrillation, catheter ablation, outcomes, redo, repeat procedures, success rate