Quantitative Magnetic Resonance Imaging Analysis of the Relationship Between Contact Force and Left Atrial Scar Formation After Catheter Ablation of Atrial Fibrillation


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Left Atrial Scar Formation After Contact Force-Guided AF Ablation. Background: Catheter contact force (CF) is an important determinant of radiofrequency (RF) lesion quality during pulmonary vein isolation (PVI). Late gadolinium enhancement (LGE) magnetic resonance imaging (MRI) allows good visualization of ablation lesions.

Objective: This study describes a new technique to examine the relationship between CF during RF delivery and LGE signal intensity (SI) following PVI.

Methods: Six patients underwent PVI for paroxysmal AF using a CF-sensing catheter and following preprocedural MRI. During ablation, CF-time integral (FTI) and position was documented for each RF application. All patients underwent repeat LGE MRI 3 months later. The LGE SIs were projected onto a MRI-derived 3-dimensional left atrial (LA) shell and a CF map was generated on the same shell. The entire LA surface was divided into 5 mm² segments. Force and LGE maps were fused and compared for each 5 mm² zone. An effective lesion was defined when MRI-defined scar occupied >90% of a 5 mm² analysis zone.

Results: Acute PVI was achieved in 100%. Two hundred sixty-eight RF lesions were tagged on the LA shells and given a lesion-specific FTI. Increasing FTI correlated with increased LGE SI, which was greater when the FTI was >1,200 gs. Below an FTI of 1,200 gs, an increment in the FTI resulted in only a small increment in scar, whereas above 1,200 gs an increment in the FTI resulted in a large change of scar.

Conclusion: There is a correlation between FTI and LGE SI in MRI following AF ablation. Real-time FTI maps are feasible and may prevent inadequate lesion formation. (J Cardiovasc Electrophysiol, Vol. 25, pp. 138-145, February 2014)

atrial fibrillation, catheter ablation, contact force, left atrium, magnetic resonance imaging, pulmonary vein isolation

Drs. Sohns and Karim contributed equally to this work.

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Introduction

Circumferential pulmonary vein isolation for atrial fibrillation (AF) has evolved over the last decade and is currently recommended for symptomatic patients refractory to antiarrhythmic drug therapy. Long-term freedom from AF can be achieved in 60 to 80% of patients with additional ablation procedures often necessary to achieve the best results. Recurrences of AF are invariably associated with PV reconnection at sites of ineffective lesion formation, a finding that is corroborated by studies using late gadolinium enhancement cardiovascular magnetic resonance imaging (LGE-MRI) of the atrium following catheter ablation for AF.

Lesion formation during RFCA depends on biophysical parameters including the power delivered, duration of

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energy application, temperature and ablation catheter tip size and orientation. The TOCCATA study described a strong relationship between contact force (CF) and clinical outcome after PVI for paroxysmal atrial fibrillation (PAF) with 20 g described as the optimal mean CF.

Using quantitative MRI analysis, we sought to evaluate the hypothesis that catheter CF is a determinant of lesion formation during catheter ablation for AF.

Methods

Six consecutive patients with drug-refractory, symptomatic PAF were scheduled to undergo PVI and all clinical, imaging, and procedural data were prospectively recorded. Written informed consent was obtained from each patient prior to the procedures. All scans used for the purposes of data analysis were deemed of adequate quality for analysis by an experienced cardiovascular MRI operator. Therapeutic anticoagulation for at least 4 weeks before the procedure was mandated.

MRI Acquisition

All patients underwent cardiovascular MRI according to a standard protocol. Briefly, MRI was performed in a 1.5-Tesla Philips Achieva MR system (Philips Healthcare, Best, the Netherlands), using either a 32-channel surface coil (In vivo, Orlando, FL, USA) or a large 2-channel flex coil. To visualize LGE signal intensity (SI), a 3-dimensional ECG-triggered, free-breathing inversion recovery turbo field echo scan with respiratory navigator motion correction was performed with a pixel resolution of $1.3 \times 1.3 \times 4 \text{ mm}^3$, which was then reconstructed to $1.3 \times 1.3 \times 2 \text{ mm}^3$. Data were acquired at mid-diastole, with a 150 ms acquisition window and a low-high k-space ordering, as well as spatial presaturation with inversion recovery fat suppression. The inversion recovery delay time was determined from a Look-Locker sequence and was set at a TI intermediate between the optimal TIs to null myocardium and blood. Previous work has validated this method for reproducible visualization of the late enhancement signal from necrotic tissue. LGE scans were performed 20 minutes after contrast agent administration. The number of slices was set for complete atrial coverage (30–40 slices). To optimize visualization of the PVs, slice orientation was performed in the 4-chamber view. Images obtained with this method appear to reflect the PVs at their maximal size. Identical MRI sequences were used for images acquired prior to ablation, and 3 months after PVI.

CF Catheter System

The CF ablation setup (TactiCath Set; Endosense SA, Geneva, Switzerland) used in this study has been reported previously. It consists of the RF ablation catheter TactiCath (CF catheter), a signal processing and display unit (base station), and a splitter interfacing between CF catheter, base station, and the RF ablation generator. The CF catheter is a 7Fr, steerable, RF ablation catheter with open irrigation. An integrated fibreoptic CF sensor measures the amplitude and orientation of the force of contact between the catheter tip electrode and the tissue. The CF sensor has a resolution and sensitivity of approximately 1 g and can measure both the lateral force and the axial force independently. The individual forces and resultant force are calculated every 100 milliseconds and are displayed continuously. At the end of each RF application a lesion-specific force–time integral (FTI) is measured, which represents the total area under the force–time graph.

Ablation Procedure

All ablation procedures were performed under sedation using intravenous midazolam. Blood pressure and oxygen saturation were continuously monitored. All catheters were advanced via the right femoral vein. A 6F decapolar reference catheter was placed in the coronary sinus. A single transseptal puncture (TSP) was made through which two 8.5F SRO long sheaths were introduced (St. Jude Medical Inc., St. Paul, MN, USA). After the TSP, intravenous heparin was immediately administered to achieve an activated clotting time between 300 and 400 seconds. A 3-dimensional (3D) geometry of the LA was reconstructed using Velocity (St. Jude Medical Inc.). A wide-area circumferential ablation was performed of the right followed by the left PV pair and isolation confirmed using a circular mapping catheter (Inquiry Optima; St. Jude Medical Inc.). The RF ablation power settings were as follows: power limited to 30 W on the anterior wall and 25 W on the posterior wall, target temperature 42 °C, constant flow at 17 mL/min. Crucially, all lesions were delivered for 40–60 seconds each at a single position before ablation was interrupted and the catheter moved to a contiguous ablation site. During ablation, the CF information was available to the operator.

For further analysis of the anatomical distribution of CF and FTI, the ablation line around each PV-pair was divided into 5 sections (Fig. 1A). Acute PVI after ablation was verified by entrance block only without the use of adenosine or isoprenaline. In the event of persistent LA-PV conduction after WACA, additional lesions were delivered along the anatomical ablation line guided by the circular mapping catheter until entry block in all 4 PVs was confirmed.

Image Processing, Registration, and Analysis

The study protocol is demonstrated in Figure 2. Prior to PVI, the LA was automatically segmented from a preprocedural whole-heart balanced steady state free precession (bSSFP) scan using a previously described technique. An MRI surface shell was generated from the segmented LA. During the procedure, the MRI shell was overlaid on fluoroscopy using the Philips EP Navigator (EPN) (Philips Healthcare). The position of each RF application was recorded on the MRI shell using the point tagging feature of EPN. Alongside, the CF-sensing ablation catheter allowed the lesion-specific contact FTI to be recorded.

Force Map

The CF and FTI were recorded around the right- and left-sided PVs and the mean CF and FTI per RF application at each PV site were derived. The mean CF and FTI per patient were also calculated. A force–time integral map was generated on the preprocedural LA surface shell, which is composed of vertices $(15,141 \pm 3,653$ vertices per shell), to each of which can be assigned a force–time value. All ablation lesions were recorded on the MRI surface reconstructed shell. The FTI associated with each lesion is distributed on
a 10 mm diameter region. The FTI map on the MRI surface shell is shown in Figure 3. The FTI at an ablation lesion is distributed to its neighboring points, within a 10 mm diameter, on the surface mesh grid (right image), taking into account catheter, cardiac and respiratory motion as well as lesion formation. Within this area, the force is distributed equally to all neighboring vertices such that their total sum is the FTI (i.e., recorded FTI).

**Late Enhancement Map**

All patients underwent a repeat cardiac MRI at 3 months post ablation. As before, the LA was automatically segmented and the LGE-MRI images were manually segmented using ITK-Snap by an experienced observer, blinded to the clinical course or treatment of the patient. Manually segmented regions were projected on the LA surface using the Maximum Intensity Projection (MIP) technique.

**Force versus Late-Enhancement Comparison**

The force map was available on the preprocedural LA and the LGE-map on the 3 months LA. These were fused together using the Iterative Closest Point (ICP) algorithm, which computes an optimal affine-based registration for fusion of the 2 surfaces. Force could thus be directly analyzed with LGE data as every vertex on the fused LA shell had an associated force–time value and LGE label.

After fusion of LGE and force maps, both quantitative and qualitative comparisons were made. For a quantitative evaluation of force versus LGE, for every recorded ablation lesion, the proportion of vertices in the 5 mm radius labeled as LGE were noted. For a qualitative comparison, the force and LGE maps were visualized using custom made software. Any similarities of patterns were noted.

Based on experimental data, the force and LGE-maps were superimposed and compared for each 5 mm² zone (Fig. 2). An effective lesion was defined when scar occupied >90% of a 5 mm² analysis zone. All CF and RF ablation records were reviewed and classified as valid or not valid for CF analysis according to the suggestions of the TOCCATA study protocol.

**Follow-Up**

Acute procedural success was defined as complete PVI confirmed using a circumferential mapping catheter. AF/atrial tachycardia (AT) recurrences were defined on the basis of (1) symptoms with ECG evidence of the presence of AF/flutter/tachycardia or (2) the presence of symptomatic or asymptomatic episodes of atrial arrhythmia lasting > 30 seconds on ambulatory cardiac monitoring. Oral anticoagulation was started the day after PVI with a target INR of 2.0–3.0. Bridging with unfractionated or low molecular weight heparin was initiated 6 hours after the procedure. After hospital discharge, all patients were reviewed in the outpatient clinic 3 months after the ablation procedure, or when symptomatic arrhythmic episodes occurred. Upon every follow-up visit, patients were asked for symptoms of AF, documented arrhythmic recurrences, and current medication. Ambulatory 24-hour Holter monitoring was performed at 3 months intervals.

**Statistical Analysis**

Statistical analysis was performed using SPSS for Windows (version 19.0, SPSS Inc., Chicago, IL, USA). Continuous variables are expressed as mean ± standard deviation or as median with interquartile range if appropriate. Normally distributed data were compared using the independent Student’s t-test. For categorical variables, the chi-square test or Fisher’s exact test was performed where appropriate. A P value < 0.05 was considered as statistically significant. All tests were 2-tailed.

**Results**

**Patient Characteristics**

We studied 6 consecutive patients, aged 58 ± 6 years of whom 3 were men. Data analysis was performed on a total of 268 ablation points. The clinical baseline characteristics of the entire study population are presented in Table 1. A 3-month blanking period was observed, during which arrhythmia recurrences were treated with antiarrhythmic drugs or direct current cardioversion. No repeat ablation was performed within the blanking period. Within the first 3 months after PVI, clinical AF recurrence was documented in 1 patient. The median follow-up time per patient was 3 (interquartile range, 3–4) months.
Figure 2. Study protocol: All patients underwent 1.5 T MRI prior to the ablation procedure and 3 months later according to our standard protocol. During the pulmonary vein isolation (PVI), each radiofrequency (RF) ablation point and the force–time integral (FTI) were recorded on the preprocedural MRI shell. After PVI, a scar map was created on the postprocedural MRI shell using LGE signal intensity. The postablation scar map was then registered to the preprocedural FTI map and a scar versus FTI analysis was performed using custom made software.

Figure 3. A typical example for the force map generation: Ablation lesions are recorded on the MRI surface reconstructed shell. The force–time integral (FTI) associated with each lesion is distributed on a 10 mm diameter region. The FTI map on the MRI surface shell is shown (left image). The FTI at an ablation lesion (marked with white circle) is distributed to its neighboring points, within a 10 mm diameter, on the surface mesh grid (right image).

Ablation Procedure

All 4 PVs were successfully isolated in all study patients. There were 268 ablation records of good diagnostic quality and therefore subject to further analysis. Average procedure duration was 214 ± 25 minutes, the mean ablation time was 36 ± 8 minutes, and fluoroscopy time was 43 ± 19 minutes. A mean of 44 ± 16 RF applications were delivered per patient. There were no major complications. One asymptomatic pericardial effusion (n = 1) was noted on routine postprocedural echocardiography. Follow-up MRI scans at 3 months excluded PV stenosis.

Distribution of CF

CF distribution of the 268 ablation lesions is demonstrated in Figure 1B. The figure shows that the majority of RF applications (>85%) were delivered with a CF of between 5 and 25 g. Overall, the mean FTI per lesion was 1,021 ± 523 gs. Figure 1A shows the mean CF and FTI applied according to PV site. The lowest FTI during ablation was applied between the left-sided PVs (L5 = 768 ± 485 gs) and in the left anterior inferior and superior ridge area (L2 = 813 ± 395 gs, L3 = 784 ± 400) (Fig. 1A). The highest FTI was applied at the right anterior superior site (R1 = 1,280 ± 703 gs) and the left posterior superior site (L1 = 1,429 ± 608 gs), respectively (Fig. 1A). A total number of 84,075 vertices were analyzed.

Preprocedural CMR

The median time of preprocedural image acquisition was 3 (interquartile range, 1–10) days. The circumferential burden of LGE SI detected before any ablation procedure was very
TABLE 1
Baseline Patient Characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Patients (n = 6)</th>
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<tbody>
<tr>
<td>Age (years)</td>
<td>58 ± 6</td>
</tr>
<tr>
<td>Range</td>
<td>47–62</td>
</tr>
<tr>
<td>Sex: Male, n (%)</td>
<td>3 (50)</td>
</tr>
<tr>
<td>Paroxysmal AF, n (%)</td>
<td>6 (100)</td>
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<tr>
<td>AF duration (years)</td>
<td>6</td>
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<tr>
<td>Coronary artery disease, n (%)</td>
<td>1 (17)</td>
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<tr>
<td>Hypertension, n (%)</td>
<td>2 (33)</td>
</tr>
<tr>
<td>History of stroke/TIA</td>
<td>1 (17)</td>
</tr>
<tr>
<td>Left atrial diameter (mm)</td>
<td>43 ± 2</td>
</tr>
<tr>
<td>Range</td>
<td>42–46</td>
</tr>
<tr>
<td>Left ventricular ejection fraction</td>
<td>58 ± 2</td>
</tr>
<tr>
<td>CHA2DS2-VASC</td>
<td>1 ± 1</td>
</tr>
<tr>
<td>Range</td>
<td>1–3</td>
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low in comparison to postablation imaging and did not affect > 5% of the PV circumference. In addition, preprocedural LGE signal localized to the mitral annulus was observed, which is a common finding due to the fibroelastic nature of cardiac tissue at this site.9

Association of CF and Left Atrial Scar Formation

All postprocedural imaging were performed 3 months after the ablation procedure. Figure 4 demonstrates an example for 1 patient of LGE SI appearance after PVI. The left atrial burden of LGE SI was significantly increased after ablation in comparison with baseline. In the majority of instances, there was visually good correlation between FTI and LGE SI, as can be seen in the anterior view of Figure 4. However, visual correlation was not always present, as indicated in the posterior view of the left veins. Semi-automated analysis of the circumferential extent revealed that the LGE signal did not achieve complete encirclement of any vein pair. There was no significant difference between the amounts of LA scar burden around the right- and left-sided PVs (P = 0.75).

In this context, increasing FTI correlated with increased LGE SI, which was higher when the FTI was > 1,200 gs. Figure 5A indicates that only small increments in LGS SI are seen up to an FTI of 1,200 gs, whereas larger increments are seen at an FTI > 1,200 gs. This result can also be reproduced when regarding an effective ablation lesion as an area that is occupied by scar of lower than > 90% (range 40–90%) per 5 mm² analysis zone (Fig. 5A). In addition, Figure 5B shows that ablation lesions with no scar formation after PVI decrease when the FTI increases. On postprocedural imaging, gaps in the ablation lines were predominantly observed in areas of low CF (e.g., L2, L3, R4), especially at PV sites where the FTI was < 1,200 gs.

Discussion

Main Finding

This study describes a new method to examine the relationship between CF, FTI, and LA scar formation following PVI. The main findings are as follows: (1) there is a correlation between FTI and CMR LGE SI following catheter ablation for AF and (2) CF distribution maps can be produced using CMR/fluoroscopy overlay.

Atrial Scar and PV Reconnection

Durable RF lesion formation is dependent on several parameters, including catheter tip electrode size, power, catheter tip temperature, and catheter-to-tissue CF. Previous work evaluating the role of CMR in assessment of the LA after PVI has used LGE to identify areas of scar before and after ablation.3,5,7,21 During PVI it is necessary to achieve electrical continuity of circumferential lesions and in this context recent data demonstrated a strong relationship between CF and lesion formation.14,22,23 Acute PVI in patients with AF is usually achievable, but recurrence associated with PV reconnection is a common finding.1,20 Recent studies have evaluated the ability of LGE MRI to evaluate the integrity of LA scar lesions and this is a potentially useful feedback tool to assess whether a successful lesion was placed.7,24-27 In this context, Arujuna et al. demonstrated that acute PVI is achieved by a combination of reversible and irreversible circumferential tissue injury at the junction between the PVs and the LA with a higher incidence of AF recurrence associated with a greater extent of reversible ablation injury,7 which in turn is due at least in part to suboptimal tissue contact. This study shows that gaps in the ablation line were predominantly observed in areas of low CF (e.g., L2, L3, R4), especially at PV sites where the FTI was < 1,200 gs. FTI maps (Figs. 2, 3 and 4) are feasible and, by illustrating areas of low CF to the operator during a procedure, have the potential to guide adequate lesion formation.

CF Parameters

In the TOCCATA10,11 and EFFICAS12 studies, an average CF of nearly 20 g was associated with higher long-term freedom from AF recurrence. Also, ablations with CF < 10 g and FTI < 400 gs were associated with unstable catheter contact and reduced patient outcome at 12 months. From the TOCCATA study it is reported that the success rate of PVI increases significantly with increasing FTI,10,11 which is supported by our findings (Fig. 5). Although we have shown a strong correlation between FTI and LGE SI when the FTI is > 1,200 gs, only small increments in LGE SI are observed up to a FTI of 1,200 gs, suggesting that the relationship is not as direct as might be expected intuitively. In EFFICAS I, the authors concluded that to achieve durable successful PVI, a target CF of 20 g is recommended, with a minimum CF of 10 g and an absolute minimum FTI of 400 gs per individual ablation lesion.12 Pulmonary vein reconnection is a common finding at repeat procedures, and may occur because of atrial injury, which is either nonpermanent but transmural or nontransmural but permanent, both patterns of which are inevitably associated with acute atrial edema and cannot possibly be distinguished by CMR at present.28,29 However, the apparently high FTI (> 1,200 gs) at which a firm relationship exists with LGE SI may be explained by the limited capacity of CMR to distinguish between partial and full thickness atrial scar: an underestimation of the area of transmural scar will bias the relationship toward an overestimation of the FTI at which effective lesions (as defined by CMR SI criteria) are seen. Although the decline in circumferential extent of LGE SI between acute and follow-up scans was less in patients with no AF recurrence than in those with AF recurrence,7 PV
reconnection also occurs in patients without clinical arrhythmia recurrence and, therefore, caution must be exercised in relying on the use of MR-defined scar as a surrogate for electrophysiological reconnection alone.

Relationship Between LA Anatomy and CF

There is evidence from previous studies that atrial ridges and muscular folds between the ipsilateral PVs (carina area) may decrease catheter stability. In addition, sites of acute and chronic PV reconnection are more frequently located in these areas. Our data are consistent with these findings as lowest average of CF and FTI were observed at the left anterior inferior ridge (L2, L3; Fig. 1A) and the ipsilateral left- and right-sided PVs (R5, L5; Fig. 1A), while the posterior wall was represented by higher overall CF and FTI measurements. However, the applied FTI varied depending on the perivenous ablation location, with a high degree of

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Figure 4. Representative example of a patient-specific registration of a postablation left atrial scar map to the force–time integral (FTI) map. For each patient all RF lesions were tagged on the MR shells and compared to their recorded FTI. A: Individual reconstruction of the preprocedural MRI shell. B: Axial slice of the left atrium from preprocedural magnetic resonance imaging showing no preablation late gadolinium enhancement. C and D: Typical example of the FTI, and E and F, left atrial scar maps in the posterior (C and E) and anterior (D and F) view.

Figure 5. Relationship between left atrial lesion formation (%) 3 months after pulmonary vein isolation and contact force (CF) measured as force–time integral (FTI) (gs). Increasing FTI correlated with increasing LGE signal intensity. For an FTI < 1,200 gs, an increment in the FTI results in a small increment in scar, whereas for FTI > 1,200 gs an increment in the FTI results in a large change in scar formation. The figure shows different curves depending on the definition of an effective lesion ranging from 40% to 90% of scar in a 5 mm² analysis zone. B: Relationship between FTI and percentage of scar per analysis zone (no amount of scar vs 70% scar vs > 70% scar) indicating that the amount of scar per zone increases, whereas the amount of no scar decreases with increasing FTI.
variability in the CF and FTI at the PV sites between the 6 patients as indicated by the relatively large standard deviations (Fig. 1A). In this context, the TOCCATA study and recent data from Haldar et al. 33 have demonstrated that there is an important clinical impact of the average CF as low catheter tip-to-tissue CF was associated with a higher rate of AF recurrence in the follow-up period after PVI. 30,11,33 Based on the preclinical data, it is known that lower CFs result in smaller lesions and gaps may occur especially between these smaller lesions and consequently lead to an absence of durable PV isolation. 11 Focusing on the FTI alone, recent data indicate that as the FTI increased from 500 to 1,000 gs, the success rate increased significantly. 11 This is absolutely in line with our data showing that there is a good correlation between FTI and LGE MRI following AF ablation and the amount of left atrial scar increases with an FTI > 1,200 gs.

One may speculate that a real-time measurement of FTI and CF during PVI might facilitate modulation of the ablation lesion size. Suboptimal CF could be compensated for by varying the RF power and/or duration for ablation, although for this a better understanding of lesion formation in real time is needed, perhaps with the use of tissue ultrasound or MR thermometry. 14,15,22,34 The importance of an effective first RF application has been shown in the EFFICAS I study, where the authors demonstrated that the average number of ablations per segment is inversely correlated to electrical isolation. 12 This supports the idea of edema formation as a complication for subsequent ablations at the same site and finally highlights that RF application should be delivered with adequate CF and FTI levels to ensure a transmural and permanent ablation lesion.

**Study Limitations**

This is not an outcome based study. It seeks to demonstrate a new method using cardiovascular MRI to quantify the relationship between CF, FTI, and LA scar after PVI. Therefore, the patient numbers are small and follow-up of the relationship between CF and chronic PV reconnection was not assessed. However, one very useful outcome of the findings is that clear correlation between CF, FTI, and LGE-MRI demonstrates that LGE-MRI could be used as a surrogate biomarker for clinical trials that seek to investigate the effects of CF on ablation outcomes.

As mentioned in the results section, the majority of regions showed good visual correlation between FTI and LGE SI. However, there were regions where the correlation was less marked. This can be explained by several factors. First, there will be inherent errors in the colocalization of the catheter-derived FTI data and the imaging-derived LGE data, including the accuracy of the coregistration and compensation of cardiorespiratory motion. We have tried to minimize these by recording the FTI information directly on MRI-derived anatomical models. Second, the formation of lesions is not purely dependent on FTI but also on other factors such as the thickness of the substrate, the RF power and application duration. It is likely that using a parameter that combines these variables instead of using just FTI alone would generate parameter maps that were more correlated with LGE SI. Exploration of parameters that are dependent on this multi-variable approach will be the focus of future work.

Elimination of the PV potentials recorded from a circular mapping catheter was the primary endpoint for PVI in this study, which is in line with the current guidelines. 1 In addition, the demonstration of exit block is also considered as an important end point. 1 Furthermore, the administration of isoproterenol or adenosine to identify dormant PV conduction can be useful. 35,36 However, the role of inducibility testing as an end point in clinical routine is still debated. 1

**Conclusions**

There is a good correlation between FTI and LGE MRI following catheter ablation of AF. An FTI of 1,200 gs is associated with atrial scar as defined by CMR. Real-time FTI maps are feasible and may prevent inadequate lesion formation.

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