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Comparisons of Procedural Characteristics and Clinical Outcomes between SMARTTOUCH® SURROUNDFLOW Catheter and Other Catheters for Atrial Fibrillation Radiofrequency Catheter Ablation: A Systematic Literature Review

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Comparisons of Procedural Characteristics and Clinical Outcomes between SMARTTOUCH[®] SURROUNDFLOW Catheter and Other Catheters for Atrial Fibrillation Radiofrequency Catheter Ablation: A Systematic Literature Review

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15 Abstract

Background: SMARTTOUCH[®] SURROUNDFLOW (STSF) catheter is the new generation of SMARTTOUCH (ST) catheter with an upgraded irrigation system for radiofrequency catheter ablation (RFCA) in patients with atrial fibrillation (AF). Methods: This systematic literature review searched the major English and Chinese bibliographic databases from 2016 to 2022 for any original clinical studies assessing the STSF catheter for RFCA in AF patients. Meta-analysis with random effects model was used for evidence synthesis. Results: Pooled outcomes from 19 included studies indicated that STSF catheter was associated with a significantly shorter procedure time [weighted mean difference (WMD): -17.4 minutes, p < 0.001], shorter ablation time (WMD: -6.6 minutes, p < 0.001), and lower catheter irrigation fluid volume (WMD: -492.7 ml, p<0.001) than ST catheter. Pooled outcomes from 4 included studies with paroxysmal AF patients reported that using the STSF catheter for RFCA was associated with a significantly shorter ablation time (WMD: -5.7 minutes, p < 0.001) and a lower risk of one-year post-ablation arrhythmia recurrence (rate ratio: 0.504, p<0.001) than the SURROUNDFLOW (SF) catheter. Significant reductions in procedure time and ablation time associated with the STSF catheter were also reported in the other 4 studies using non-ST/SF catheters as the control. Overall complications of STSF catheter and control catheters were comparable. Conclusions: Using the STSF catheter was superior to using the ST catheter to conduct RFCA for AF by significantly reducing procedure time, ablation time, fluoroscopy time, and irrigation fluid volume. The superiority of the STSF catheter over the SF catheter and other non-ST/SF catheters for RFCA needs further confirmation.

5051 33 Strengths and limitations of this study

This study was a comprehensive systemic literature review including published evidence assessing all existing catheters for radiofrequency catheter ablation in patients with atrial fibrillation. In addition, the literatures search was conducted in both English and Chinese bibliographic databases. This study conducted subgroup analysis to 56 37 explore the sources of heterogeneity in the pooled outcomes and generated robust evidence for the comparisons of the outcomes associated with SMARTTOUCH® SURROUNDFLOW (STSF) catheter and SMARTTOUCH (ST) catheter. The existing evidence was insufficient to support full comparisons of ablation-related complications and 60 40 long-term clinical outcomes associated with ablation catheters.

Keywords

atrial fibrillation; radiofrequency catheter ablation; SMARTTOUCH® SURROUNDFLOW; systematic literature review; meta-analysis

1. Introduction

Radiofrequency catheter ablation (RFCA) plays a critical role in managing atrial fibrillation (AF), which affects 1.6% of the Chinese adult population and is rising in prevalence along with the aging population in China [1]. RFCA was originally conducted using a non-contact force (CF)-sensing catheter, whose use is now discouraged due to the inadequate lesion formation caused by insufficient CF or complications (such as cardiac perforation and atrioesophageal fistula) caused by excessive CF [2]. Thus, a CF-sensing catheter was developed to improve ablation outcomes and safety. The THERMOCOOL SMARTTOUCH® (ST) catheter is one of the CF-sensing catheters widely used for RFCA. The ST catheter is equipped with a technology that can measure the CF generated by the catheter tip on the myocardium and an irrigation system that cools the tip of the electrode catheter during ablation and allows high radiofrequency energy ablation without overheating at the electrode-tissue interface [3]. To enhance the cooling effects on the tip of the catheter electrode, surround flow (SF) technology was developed by equipping the catheter porous tip with 56 tiny holes, which make conduits for optimal fluid pressure distribution in the catheter tip. As the new generation of a catheter with advanced irrigation technology, the STSF catheter combines both CF and SF technologies to optimize ablation outcomes, protect cardiac function, and reduce the risk of developing eschar during ablation [4]. According to a meta-analysis of four clinical trials published before 2020, the STSF catheter was superior to the ST catheter in procedure outcomes by reducing the procedure time, fluoroscopy time, and catheter irrigation infusion volume [5]. However, this meta-analysis was unable to assess the robustness of the pooled evidence due to the small number of included studies. With accumulated evidence from recently published studies assessing STSF catheter ablation in patients with AF, we conducted this systematic literature review (SLR) aiming to add more evidence from multiple sources (journals published in Chinese and recent conference proceedings) and including studies comparing STSF versus (vs.) catheters other than ST to better comprehend the values of STSF catheter for RFCA in AF patients.

2. Materials and Methods

This study was designed as an SLR using major English- and Chinese-language bibliographic databases to identify published, peer-reviewed clinical studies comparing the STSF catheter against other ablation catheters for procedural characteristics and clinical outcomes associated with RFCA in AF patients. This SLR was conducted by following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) 2020 Statement [6].

2.1 Study eligibility criteria

This SLR set both inclusion and exclusion criteria to identify clinical trials or observational studies comparing the STSF catheter with other ablation catheters for AF. The study inclusion criteria are as follows: (1) including AF patients who underwent RFCA; (2) assessing STSF against any other type of ablation catheter for RFCA in adult patients with AF; (3) reporting procedural characteristics and clinical outcomes associated with ablation catheter during and/after RFCA in AF patients; and (4) designed as a clinical trial or observational study. The exclusion criteria of this SLR are as follows: (1) preclinical (in vivo or in vitro) studies, case studies, case reports, non-original research articles (e.g. correspondence, editorials, commentaries, overviews, summaries, communications, consensus guidelines) and reviews; (2) any cohort that includes patients with ablation for arrhythmias other than AF; (3) single-arm studies assessing STSF without control; (4) inadequate information.

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2.2 Information sources and search strategies

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Given that RFCA has been implemented for AF treatment for over 20 years in China, many clinical studies assessing various ablation catheters for AF have been published in Chinese clinical journals. Therefore, this SLR explored major English bibliographic databases (MEDLINE, Embase, Web of Science, and the Cochrane Library) and three major Chinese bibliographic databases (WANFANG, VIP, and China National Knowledge Infrastructure) as the data sources. To align with the time of STSF approval in 2016, the literature search period was set from January 1, 2016, to the date when the literature search was first conducted (July 31, 2022). Grey literature search was conducted by searching the proceedings of the Heart Rhythm Society annual conference, the Society for Cardiovascular Angiography and Interventions annual conference, the European Heart Rhythm Association annual conference, and the Asia Pacific Heart Rhythm Society annual conference in 2021 and 2022 for any relevant but not fully published studies. To ensure that all relevant evidence is captured, this study only combined the keywords for AF and STSF to develop the search strategy for each bibliographic database and grey literature search.

2.3 Literature selection process

Two reviewers conducted the literature selection independently after which the search hits were pooled. Then, they deleted duplicate results and identified additional studies from the left references for further eligibility assessment, which included the exclusion of irrelevant references and retrieving full publications of the relevant references. The developed inclusion and exclusion criteria were used to determine the study eligibility after a full publication review. The exclusion reasons during the literature selection process were documented for records. Any disagreement on study eligibility between the two reviewers was resolved by consulting with the study lead.

36 100 2.4 Data collection process

39¹⁰¹ Excel-based data extraction forms were developed specifically to guide the data collection from the full 40 102 publications of included studies. The designed data extraction form was tested using one included study to align 42 103 with definitions of the planned data items for extraction. Two reviewers were fully trained on how to use the data ⁴³104 extraction forms and the definitions of data items. The two reviewers conducted data extraction independently. The 45 105 extracted information from the two reviewers was further cross-checked by the third reviewer, which corrected any **46** 106 inconsistent information by verifying the information source. The study lead reviewed all extracted information for 48107 any abnormal information before evidence synthesis.

⁵⁰108 2.5 Data items

52 5<u>3</u> 109 The full publication of the included studies was reviewed to collect the following information: (1) study 54 110 55 characteristics such as country setting, study design, and patient inclusion and exclusion criteria; (2) study arm 56 1 1 1 information including the arm definition, sample size, and patient baseline characteristics (demographics, AF-57 58 112 related clinical characteristics, and comorbidities); (3) ablation catheter type; (4) outcome measures that included 59113 procedural characteristics (procedure time, ablation time, fluoroscopy time, irrigation fluid volume), clinical 60

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118 2.6 Study risk of bias assessment

13119 This SLR used Newcastle-Ottawa Scale (NOS) [7] to assess the study quality of the included studies. Based 15¹²⁰ on the recommendation from previous research [8], this SLR classified included studies as good quality (NOS 8-9), 16121 fair quality (NOS 5-7), and poor quality (NOS 0-4). This SLR included one randomized clinical trial, which was 17 18 ¹²² published as a conference abstract and didn't provide adequate information for the quality assessment using the 19 123 Jadad score [9]. Two reviewers used NOS to assess the fully published studies independently. Any disagreement on 21 124 assessment was discussed with the study lead to reach a consensus.

23 1 25 2.7 Effect measures

25 26 126 This SLR extracted any reported effect measures from the included studies. The extracted effect measures 27 1 27 were standardized according to their original definitions in the included studies and the selected effect measures for 20 29¹²⁸ evidence synthesis included procedural characteristics and clinical outcomes. This SLR used weighted mean 30 1 2 9 difference (WMD) to present the pooled procedural characteristics for the comparisons of procedure time, ablation **32** 130 time, fluoroscopy time, and catheter irrigation fluid volume. The pooled clinical outcomes for the comparisons of ³³131 acute procedural success of PVI, one-year post-ablation arrhythmia recurrence, and RFCA-related overall 35 1 32 complications were presented with a rate ratio (RR).

37 133 2.8 Synthesis methods

39 40 ¹³⁴ The extracted data were standardized and categorized by AF types (paroxysmal AF, persistent AF, and 41 135 unspecified AF); control catheter types (ST, SF, CELSIUS[®] catheter, DiamondTempTM, and NAVISTAR[®]); patient 42 43 136 characteristics [age, gender distribution, AF type distribution, disease duration after the diagnosis of AF, left ⁴⁴137 ventricular ejection fraction (LVEF), left atrium diameter, CHA₂DS₂ VASc, and comorbidities]; and effect 45 46 1 38 measures for RFCA procedural characteristics and clinical outcomes. The reported outcomes from the included 47 48 139 studies comparing STSF vs. the same control catheter were first pooled for evidence synthesis using a pairwise 49 1 40 meta-analysis method, which used a random-effect model to consider the variance between the included studies and 50 51 ¹⁴¹ within each included study. Heterogeneity in the conducted meta-analysis was assessed using the I^2 method. The 52 1 4 2 included studies were stratified by AF type for subgroup analysis if the heterogeneity in the pooled outcomes was 53 54 ¹⁴³ significant. Further exploration of potential heterogeneity sources was conducted by excluding the studies reporting 55 144 different patient characteristics if significant heterogeneity was still detected in the pooled outcomes from the 56 57 145 subgroup analysis. The leave-one-out sensitivity analysis was conducted to determine the robustness of the overall ⁵⁸ 146 pooled outcomes for the meta-analysis including 3 or more eligible results. The Egger's test was also performed to 59 60 1 47 assess publication bias for overall pooled outcomes from 10 or more eligible results. This SLR used the statistical

software R to conduct the described analyses. Original results from included studies were reported when the metaanalysis was not feasible.

3. Results

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10 ¹⁵¹ 3.1 Study selection

This study initially identified 373 unique references from the search of the included English and Chinese bibliographic databases. One-hundred-eighty-two were excluded due to irrelevance following the review of the titles and abstracts of the initial batch of papers. Following the study eligibility assessment of the full publications of the remaining 191 papers, 25 met the inclusion criteria. The search of conference proceedings and review articles identified two additional eligible studies. Thus, a total of 27 studies are included in our SLR. The flowchart of the study identification process is illustrated in Figure 1.

²²158 3.2 Characteristics and qualities of included studies

25 1 59 The included 27 studies assessed the procedural characteristics and clinical outcomes associated with STSF <mark>26</mark> 160 relative to ST (in 19 studies), SF (in 4 studies), and other four non-STSF/SF catheters (1 study for each non-28161 STSF/SF catheter), respectively. This SLR only included one randomized clinical trial and the rest of the included ²⁹ 30¹⁶² studies were observational studies, including 13 retrospective studies and 13 prospective studies. This SLR 31 1 63 included 4 studies published in Chinese. The studies published in English included 3 studies from the United States, 32 33 ¹⁶⁴ 13 studies from Europe, and 7 studies from other regions. Among the included studies, 17 studies were fully 34165 published and 10 studies were published in conference proceedings. Even though all these studies included patients 36 166 who underwent RFCA for AF, 7 studies solely included patients with paroxysmal AF, 1 study only included 37 167 patients with persistent AF, and 19 studies included patients with either paroxysmal or persistent AF. According to 39 168 the reported patient baseline characteristics in these included studies, the study patients were characterized with 40 169 relatively old age (mean age range: 58.0-67.5 years), high CHA₂DS₂ VASc score (mean range: 1.3-2.7), and 42 170 prevalent cardiovascular comorbidities, which included hypertension (30.4%-98.0%), coronary heart disease 43 44 171 (8.3%-29.2%), and heart failure (17.8%-41.7%). Of the 17 studies assessed for study quality, 7 studies had good 45 172 quality and 10 studies had fair quality. The study characteristics and main extracted information from these 46 47 173 included 27 studies are summarized in Supplementary Table 1.

3.3 Synthesized evidence from the included studies comparing the STSF catheter with the ST catheter 49174

⁵¹175 Of the included 19 studies comparing STSF with ST, 13 studies [10-22] included patients with unspecified AF 53176 (persistent or paroxysmal AF) and 6 studies [23-28] included patients with paroxysmal AF. The synthesized 54 55 177 outcomes included procedural characteristics (procedure time, ablation time, fluoroscopy time, and irrigation fluid 56178 volume), primary clinical outcomes (acute procedural success of PVI, one-year post-ablation arrhythmia 57 58 ¹⁷⁹ recurrence, and overall complications), and other ablation-related clinical outcomes that included foley catheter use, 59₁₈₀ diuretics use, and eschar development.

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3.3.1 Procedural characteristics - Procedure time

Overall, nine included studies with 10 eligible results [10-15, 23-25] report RFCA procedure time (876 operated with STSF and 762 operated with ST). The overall pooled outcomes from nine included studies showed that STSF was associated with significantly shorter procedure time than ST (WMD: -17.4 minutes, 95% CI: -25.3 to -9.4 minutes, p<0.01); however, this pooled outcome has considerable heterogeneity [I² = 76%, p<0.01]. The pooled outcomes from the stratified studies by AF types identified significantly shorter procedure time associated with the STSF catheter from the studies with unspecified AF patients (WMD: -18.7 minutes, 95% CI: -27.6 to -9.7 minutes, p<0.001) but not from the studies with paroxysmal AF patients (WMD: -14.7 minutes, 95% CI: -32.3 to 2.9 minutes, p=0.101). Because the heterogeneity of the pooled evidence from the 6 studies with unspecified AF patients was still significant, we reviewed these six studies to further explore the potential heterogeneity sources.

We found that 2 studies [10, 11] and a subgroup within one study [12] included patients who were likely to be different from those in other studies in AF duration, left atrial diameter/volume, the proportion of patients with paroxysmal AF, and proportion of patients with cardiomyopathy. After excluding the results from these four studies in the meta-analysis, the shorter procedure time of the STSF catheter remained statistically significant (WMD: -25.9 minutes, 95% CI: -33.0 to -18.8 minutes, p<0.001) with non-significant heterogeneity (I²=21%, p=0.29), suggesting that these characteristics are potential heterogeneity sources.

The leave-one-out sensitivity analysis indicated that the point estimation of the overall pooled difference in procedure time between the STSF catheter and the ST catheter had a relatively narrow range (from -15.2 minutes to -19.9 minutes). In addition, Egger's test did not detect significant publication bias for the reported difference in procedure time between the STSF catheter and the ST catheter from the included 9 studies (p=0.768). The pooled difference in the procedure time between the STSF catheter and the ST catheter is illustrated in Figure 2. The other reported outcomes are listed in Supplementary Files.

203 3.3.2 Procedural characteristics - Ablation time

42²⁰⁴ Twelve included studies [10-17, 23-26] with 13 eligible results reported the ablation time associated with 43 205 using STSF and ST to conduct RFCA in 1,870 patients with AF (992 operated with STSF and 878 with ST). The 45 206 pooled differences in the ablation time of the two catheters favored the STSF catheter (WMD: -6.6 minutes, 95% ⁴⁶207 CI: -12.5 to -0.6 minutes, p=0.031) with significant heterogeneity (I²=98%, p<0.01). To control the potential 48208 heterogeneity associated with AF type, this SLR performed a subgroup meta-analysis for this outcome by including 49 50²⁰⁹ the stratified studies by the AF types of study patients (paroxysmal AF vs. unspecified AF). The pooled difference 51210 in ablation time between the two catheters remained significant in the meta-analysis of the studies with unspecified 52 53²¹¹ AF patients (WMD: -8.6 minutes, 95% CI: -16.9 to -0.4 minutes, p=0.039) but was not for the studies with 54212 paroxysmal AF patients (WMD: -1.1 minutes, 95% CI: -4.8 to 2.6 minutes, p=0.555). However, heterogeneity in 56²¹³ the subgroup meta-analysis of the studies with unspecified AF patients was still significant ($I^2=98\%$, p<0.01) and ⁵⁷214 brought our attention to further explore the potential heterogeneity sources in these studies. By reviewing the 59215 reported patient baseline characteristics from these included studies, we found 4 studies [10-12, 16] with obviously 60

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216 different patient characteristics (AF duration, left atrial diameter/volume, the proportion of paroxysmal AF, 217 proportion of patients with myopathy, Ablation Index value, baseline CHA₂DS₂ VASc score, saline flow rate) from 218 the other studies. After excluding these four studies from the subgroup meta-analysis, the pooled difference in 219 ablation time still favored the STSF catheter with statistical significance (WMD: -22.5 minutes, 95% CI: -24.3 to -10 220 20.6 minutes, p < 0.001) and low-level of heterogeneity (I²=0%, p=0.69), suggesting that these characteristics are 11 221 potential heterogeneity sources.

13 222 The overall pooled difference in ablation time between the two catheters from the leave-one-out sensitivity 14 15²²³ analysis ranged from -7.5 minutes to -5.1 minutes. No significant publication bias was detected from the included 16224 12 studies comparing the two catheters for ablation time during RFCA (Egger's test: p=0.450). The pooled 17 18²²⁵ difference in the ablation time between the STSF catheter and the ST catheter is illustrated in Figure 3. The other 19226 reported outcomes are listed in Supplementary Files.

21 ₂₂₇ 3.3.3 Procedural characteristics - Irrigation fluid volume

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24 2 28 Six included studies [10-12, 23-25] with 1229 AF patients (629 operated with STSF and 600 with ST) ²⁵ 229 26 reported catheter irrigation fluid volume during RFCA. The meta-analysis of the reported irrigation fluid volume 27 2 30 associated with the two catheters from the 6 studies indicated a significantly lower irrigation volume for using 28 29²³¹ STSF to conduct RFCA (WMD: -492.7 mL, 95% CI -646.1 to -339.3 mL, p < 0.001). However, this pooled outcome 30 2 3 2 was associated with significant heterogeneity ($1^2=94\%$, p<0.01). These six included studies were stratified by 31 32 233 patient AF type (paroxysmal AF vs. unspecified AF) to conduct a meta-analysis for the control of potential 33 234 heterogeneity associated with AF types. The pairwise meta-analysis of the three studies with paroxysmal AF 34 35 2 35 patients [23-25] confirmed the significant reduction of catheter irrigation fluid volume (WMD: -538.6 mL, 95% CI: ³⁶ 236 37 -621.2 to -456.1 mL, p < 0.001) with moderate but non-significant heterogeneity (1²=38%, p=0.20) for RFCA 38237 conducted by STSF catheter. However, significant heterogeneity ($1^2=94\%$, p<0.01) was found for the pooled ³⁹238 difference in catheter irrigation fluid volume (WMD: -461.4 mL, 95% CI: -739.2 to -183.6 mL, p=0.001) between 41 2 39 the two catheters from the left three studies with unspecified AF patients [10-12]. No further exploration of 42 43²⁴⁰ heterogeneity resources for this pooled outcome due to a limited number of studies reporting this outcome measure. 44 241 The overall pooled difference in catheter irrigation fluid volume between the two catheters from the leave-one-out 45 46 ²⁴² sensitivity analysis ranged from -532.1 mL to -427.3 mL.

47 243 The pooled difference in the catheter irrigation fluid volume between the STSF catheter and the ST catheter is 48 49 2 4 4 illustrated in Figure 4. The other reported outcomes are listed in Supplementary Files.

51 2 4 5 3.3.4 Procedural characteristics - Fluoroscopy time

53 54 246 Eight included studies [10-13, 23, 25-27] compared fluoroscopy time between STSF catheter and ST catheter 55 247 used to conduct RFCA (four studies [10-13] with unspecified AF patients and four studies [23, 25-27] with 56 57 248 paroxysmal AF). The overall pooled difference in fluoroscopy time during RFCA between the two catheters ⁵⁸249 showed that the STSF catheter was associated with significantly shorter fluoroscopy time than the ST catheter 59 60 2 50 (WMD: -1.6 minutes, 95% CI: -2.8 to -0.3 minutes, p=0.014); however, this pooled outcome was associated with

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251 significant heterogeneity ($I^2=77\%$, p<0.014). The included studies were further stratified by the patient AF types 252 (paroxysmal AF vs. unspecified AF) to conduct subgroup meta-analysis to explore potential heterogeneity 253 associated with AF types. The subgroup meta-analysis including studies with paroxysmal AF patients confirmed 254 the significantly shorter fluoroscopy time during RFCA conducted by STSF catheter (WMD: -1.4 minutes, 95% CI: 10255 -2.2 to -0.6 minutes, p<0.001) with a low level of heterogeneity ($I^2=8\%$, p=0.35) [23, 25-27]. However, the pooled 11 256 difference in fluoroscopy time between the two catheters from the subgroup meta-analysis of 5 eligible results from 12 13257 the four studies with unspecified AF patients [10-13] didn't reach statistical significance and also had substantial 14 -- 258 heterogeneity. No further exploration of heterogeneity sources for this subgroup meta-analysis due to a limited 15 16259 number of included studies reporting this outcome. The overall pooled difference in fluoroscopy time between the 17 18²⁶⁰ two catheters from all included studies in the leave-one-out sensitivity analysis ranged from -1.9 minutes to -1.4 19261 minutes. 20 21 ²⁶²

The results of the meta-analysis of the included 8 studies reporting fluoroscopy time associated with STSF 22 263 catheter and ST catheter are illustrated in Figure 5. The other reported outcomes are listed in Supplementary Files.

²⁴_264 3.3.5 Primary clinical outcomes

27 265 Thirteen studies [10-17, 22-24, 26, 28] reported primary clinical outcomes, including the acute procedural 28 29²⁶⁶ success of PVI, one-year post-ablation cardiac arrhythmia recurrence, and overall complications related to RFCA. 30 2 6 7 The overall pooled RR for acute procedure success [10, 12, 14-17, 26, 28], one-year post-ablation cardiac 31 32²⁶⁸ arrhythmia recurrence [10, 13, 17, 22, 28], and overall complications [11, 14, 16, 17, 23, 24, 26, 28] from these 33 269 studies were 0.995 (95% CI: 0.976 to 1.014, p=0.592), 0.727 (95% CI: 0.355 to 1.490, p=0.384), and 0.766 (95% 35 270 CI: 0.299 to 1.959, p=0.578), respectively, without reaching statistical significance. Among these three pooled ³⁶271 outcomes, only the pooled RR for one-year post-ablation arrhythmia recurrence between the two catheters was 38272 associated with significant heterogeneity ($I^2 = 68\%$, p < 0.01). Subgroup meta-analysis including stratified studies by ³⁹ 273 patient AF types (paroxysmal AF vs. unspecified AF) was unable to homogenize the pooled RR for one-year post-41 274 ablation cardiac arrhythmia recurrence between the two catheters. The leave-one-out sensitivity analyses for the 42 43²⁷⁵ three pooled outcomes observed a narrow range for pooled RR for the acute procedural success of PVI (0.993 to 44 276 (0.999) but wide ranges for one-year post-ablation cardiac arrhythmia recurrence ((0.555 to 0.929)) and overall 45 46²⁷⁷ complications (0.600 to 0.927). All reported outcomes are illustrated in Supplementary Files.

48278 3.3.6 Other ablation-related clinical outcomes

50 -1 279 Three included studies reported other ablation-related clinical outcomes. Two studies [23, 24] (502 51 52 280 paroxysmal AF patients) reported significantly lower utilizations of the foley catheter [RR: 0.506, 95% CI 0.393 to 53 54²⁸¹ 0.651, p<0.001] without heterogeneity (I²=0%, p=0.68). One study [25] with 47 paroxysmal AF patients reported 55 282 STSF catheter was associated with a significantly lower risk of diuretics use (RR: 0.050, 95% CI: 0.003 to 0.819, 56 57 283 p=0.036). In addition, one study [27] with 68 paroxysmal AF patients reported that STSF catheter was associated ⁵⁸284 with a reduced risk of eschar formation during ablation without reaching statistical significance (RR: 0.143, 95% CI 59 60 2 8 5 0.008 to 2.663, p=0.192). The pooled outcomes are illustrated in Supplementary Files.

3.4 Synthesized evidence from the studies comparing the STSF catheter with the SF catheter

This SLR identified 4 studies [29-32] comparing STSF with SF for procedural characteristics and clinical outcomes in AF patients. One study [29] with a small sample size (26 using STSF catheter and 26 using SF catheter) reported significantly longer RFCA procedure time (mean difference: 20.0 minutes, 95% CI: 2.9 to 37.1 minutes, p=0.022) and fluoroscopy time (mean difference: 4.0 minutes, 95% CI: 1.1 to 6.9 minutes, p=0.007) in the 11²⁹¹ STSF group. The meta-analysis including 2 studies [29, 30] with 252 patients did not identify significant 12 292 differences in both acute procedure success of PVI and ablation-related complications between the two catheters. 13 293 One study [31] with 395 patients with paroxysmal AF (298 using STSF and 97 using SF) reported significantly 15²⁹⁴ shorter ablation time (mean difference: -5.7 minutes, 95% CI: -8.4 to -3.1 minutes, p<0.001). The pooled RR for one-year post-ablation arrhythmia recurrence between the two catheters from the two studies [31, 32] favored the 17 296 STSF catheter with statistical significance (RR: 0.503, 95% CI: 0.379 to 0.667, p < 0.001, heterogeneity test: $I^2=0\%$, 18₂₉₇ p=0.98) when compared to SF catheter. The reported RFCA-related outcomes from the four studies are summarized 20²⁹⁸ in Table 1. The pooled outcomes are illustrated in Supplementary Files as well.

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		Tab	le 1. Summary of the pooled differences in RF	CA-related out	comes between STSF cathe		675 ter 79 AF pa	tients.			
						din	on	Pooled o	utcomes		
	AF type	Outcome type	Outcome	Number of studies	Sample size	Outcome g measure o	Point estimation	95%CI lower	95%CI upper	P valu	
		Procedural	Procedure time (minutes) [29]	1	STSF: 26; SF: 26	WMD ES	estimation estimation Enseignem	2.9	37.1	0.022	
	Unspecified	characteristics	Fluoroscopy time (minutes) [29]	1	STSF: 26; SF: 26	WMD ated	202.0 Inem	1.1	6.9	0.007	
	AF	Clinical outcomes	Acute procedural success of PVI (%) [29]	1	STSF: 26; SF: 26	DD 5	5 <u>5</u> 00	0.928	1.078	1.000	
		Chinear outcomes	Any complications [29, 30]	2	STSF: 126; SF: 126	RR an	t Superieur (0.052	10.574	0.828	
			Procedural	Ablation time (minutes) [31]	1	STSF: 298; SF: 97	WMD dat	eur (-8.4	-3.1	<0.00
Paroxysmal	characteristics	Radiofrequency energy use (J) [31]	1	STSF: 298; SF: 97	WMD and		-9,629.5	-1,235.5	0.011		
	AF	Clinical outcomes	Acute procedural success of PVI (%) [31]	1	STSF: 298; SF: 97	RR ŋ	.	0.985	1.015	1.000	
		Chinear outcomes	One-year post-ablation arrhythmia recurrence rate (%) [31]	1	STSF: 298; SF: 97	RR AI tra	6 504	0.368	0.689	<0.00	
	Persistent	Persistent Clinical outcomes	One-year post-ablation arrhythmia recurrence rate (%) [32]	1	STSF: 74; SF: 74	RR ining	2 500	0.262	0.956	0.036	
	AF		Any complications [32]	1	STSF: 74; SF: 74	RR and	2000	0.378	10.587	0.415	
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3.5 Reported outcomes between STSF catheter and non-ST/SF catheter

302 This SLR identified 4 studies comparing STSF with four non-ST/SF catheters which were the CELSIUS® 303 catheter [33], DiamondTemp[™] catheter [34], DirectSense catheter guided by Rhythmia[™] System [35], and 304 NAVISTAR[®] catheter [36]. The 4 studies reported that the STSF catheter was associated with significantly shorter 10 305 RFCA procedure time than the DiamondTemp[™] catheter(mean difference: -20.6 minutes, 95% CI: -32.5 to -8.7 12306 minutes, p<0.001) and NAVISTAR[®] catheter (mean difference: -30.0, 95% CI: -39.9 to -20.1 minutes, p<0.001); 13₃₀₇ significantly shorter ablation time than NAVISTAR® catheter (mean difference: -15.0 minutes, 95% CI: -20.5 to -15 308 9.5 minutes, p < 0.001; and significantly shorter fluoroscopy time than DirectSense catheter guided by RhythmiaTM 16 ₃₀₉ 17 System (mean difference: -7.0 minutes, 95% CI: -10.9 to -3.1 minutes, p<0.001) and NAVISTAR® catheter (mean 18310 difference: -2.0 minutes, 95% CI: -2.8 to -1.2 minutes, p < 0.001). However, one study with 116 patients with 20³¹¹ persistent or paroxysmal AF [34] reported that the STSF catheter was associated with a significantly longer ablation 21 3 1 2 time than the DiamondTemp[™] catheter (mean difference: 4.1 minutes, 95% CI: 2.0 to 6.2 minutes, p<0.001). None 23 313 of these 4 studies reported any significant differences in the rates of ablation-related overall complications between 24 3 1 4 the STSF catheter and the four non-ST/SF catheters.

4. Discussion

29 316 Compared to a similar SLR published in 2020 [5], our SLR was designed with an expansive search period and 30317 search scope which has resulted in the inclusion of a larger pool of studies and much more robust evidence to 31 3 1 8 demonstrate the values of STSF catheter for RFCA in AF patients. For example, our SLR captured and studied 32 319 significantly more studies than the aforementioned SLR (27 studies vs. 4 studies). Additionally, not only did our 33 34 320 SLR include studies comparing STSF with ST but also with SF and other ablation catheters in AF patients; in 35 321 contrast, the other SLR only included studies comparing STSF with ST. Furthermore, our SLR synthesized 36 3 2 2 evidence for more outcomes than the previous SLR and conducted additional heterogeneity analysis and 37 323 publication bias assessment to make the pooled findings more robust. Therefore, our SLR should be more 38 324 informative regarding the clinical values of STSF for RFCA in AF patients.

39 40 41 325 41 326 According to the studies reviewed in this SLR, the STSF catheter was mainly studied in comparison with the ST catheter in AF patients. As the STSF catheter evolved from the ST catheter by upgrading the irrigation system 42 3 27 to improve procedural characteristics, the STSF catheter contains all the features of the ST catheter such as the 43 328 contact force technology and advanced irrigation system that provides uniform cooling at half the flow rate of ST 44 329 catheter and facilitates the process of fluid management [4]. The pooled evidence for the outcomes that were 45 330 46 330 compared between the two catheters in our SLR aligned with the expected impact of the advanced irrigation system 47 331 of STSF. For example, the pooled evidence showed that the STSF catheter significantly save RFCA procedure time 48332 (17.4 minutes, p < 0.001), ablation time (6.6 minutes, p = 0.031), and fluoroscopy time (1.6 minutes, p = 0.016) with 49 3 3 3 significantly reduced catheter irrigation fluid volume (492.7 mL, p<0.001) relative to ST catheter. These benefits 50 334 could potentially improve the performance efficiency of RFCA and enhance the capacity of conducting RFCA in 51 534 52 335 hospital settings. In addition, reduced fluoroscopy time could help with reducing occupational health hazards 53 336 during RFCA. Moreover, the substantial reduction in the irrigation volume of STSF could substantially limit the 54337 cardiac burden due to catheter irrigation infusion and make ablation treatment safer to treat AF with heart failure.

55 338 The pooled evidence also indicates that primary clinical outcomes, including acute procedure success of PVI, 56 -- 339 one-year post-ablation arrhythmia recurrence, and overall complications, are comparable for the STSF catheter and 57 57 58³⁴⁰ ST catheter. A possible explanation is that both catheters use the same contact force technology, which is the 59341 primary driver of the ablation effects [37]. However, the advanced irrigation system of the STSF could bring more 60 3 4 2 clinical benefits to AF patients with heart failure. According to the reported patient characteristics from the

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3 343 included studies, AF patients are characterized by old age (mean age range: 58.0-67.5 years old) and a high 4 344 prevalence of heart failure (17.8% to 41.7%). The fluid infusion through the catheter during RFCA could stress the 5 345 heart and deteriorate the cardiac function in patients with heart failure. Even though RFCA has been proven to 6 346 improve cardiac function (indicated by LVEF [38]), previous studies observed a high rate of developing acute heart 7 8 347 failure (4.9% to 26.1%) after open-irrigated catheter ablation [39-41]; the development of acute heart failure after 9 348 ablation in these studies was likely due to excessive infusion fluid during ablation procedure as patients with 10 349 developed acute heart failure after ablation was associated with significantly higher net fluid infusion volume 11 12350 during ablation than those without developing acute heart failure. Thus, the substantial reduction of the catheter 13 351 irrigation infusion volume of the STSF catheter could lower the burden of RFCA on the cardiac load and 14352 potentially reduce the risk of acute heart failure after RFCA [42]. In addition, the shortened ablation time through 15 353 STSF could make RFCA more tolerable for AF patients with heart failure who are prone to developing respiratory 16 17³⁵⁴ distress with the flat position required by the ablation procedure [43]. Even though this SLR didn't identify any 18 355 included studies directly assessing the impact of STSF on cardiac function and risk of acute heart failure, three of 19356 the included studies [23-25] did report that STSF catheter was associated with significantly reduced uses of 20357 diuretics and urinary catheter, the treatments often used to reduce fluid retention and the risk of acute heart failure 21 358 22 359 23 359 after RFCA for AF. Since AF patients are often complicated with heart failure due to old age and other cardiovascular conditions, future research should be encouraged to confirm the cardiac function-related benefits of 24 360 STSF and generate robust evidence to inform clinical practices and guidelines regarding the appropriate 25 361 applications of STSF catheter ablation for AF. Another potential clinical benefit of the improved irrigation system 26 3 6 2 of STSF is the reduction of the risk of eschar due to the amplified cooling effects. Eschar occurs more often with ²⁷ 363 28 unipolar radiofrequency ablation that generates excessive local temperature leading to the formation of eschar on 20 29³⁶⁴ the tissue surface; carbonization; and thromboembolic complications; and even damage to the esophagus and 30 3 6 5 atrium, which induces serious complications such as atrial esophageal fistula, atrial rupture, and pulmonary vein 31 366 stenosis [44]. Because the STSF catheter has a more advanced irrigation system than the ST catheter, it is expected 32 367 that the STSF catheter could be associated with a lower risk of eschar formation than the ST catheter. However, this ³³₃₆₈ 34 SLT didn't identify robust evidence to support this clinical benefit of STSF as only one study with a small sample 34 35 ³⁶⁹ size reported a non-significant trend for the reduced risk of eschar for STSF catheter [27].

36370 This SLR also identified 4 eligible studies comparing the STSF catheter with SF catheter and other 4 studies 37 371 comparing the STSF catheter with non-ST/SF catheters. The pooled evidence from two eligible studies identified 38 372 significantly reduced one-year post-ablation arrhythmia recurrence for STSF catheter relative to SF catheter. 39 373 40 373 41 374 Because these SF catheters were equipped with a similar irrigation technology as the STSF catheter but without contact force technology, which mainly drives the ablation outcomes [37]. The reported outcomes from the four 42 375 studies comparing the STSF catheter with contemporary non-ST/SF catheters suggested that the STSF catheter 43 376 could be better than the non-ST/SF catheter regarding the procedure characteristics, which included procedural 44 377 time, ablation time, and fluoroscopy time. However, these findings are not robust due to a limited number of studies 45 378 46 378 47 379 (only one study comparing STSF with each non-ST/SF catheter) and the small sample size in each included study.

The generated evidence from this SLR should be interpreted with caution as most of the included studies were 48380 observational studies. The common limitations, such as selection bias, measurement bias, and unknown 49381 confounders, of observational studies could introduce heterogeneity in the pooled evidence. That might explain ⁵⁰382 why most of the overall pooled outcomes in this SLR had significant heterogeneity. This SLR did recognize that 51 52³⁸³ AF type could an important heterogeneity source as the persistent AF usually requires additional substrate ablation 53 384 beyond PVI than paroxysmal AF. Thus, this SLR stratified the included studies by patient AF types to control 54385 heterogeneity in the pooled outcomes. This strategy seems to work well with the studies only including paroxysmal 55 386 AF patients as the pooled outcomes, including the differences in ablation time, irrigation fluid volume, fluoroscopy 56 387 time, and overall complications from these studies don't have significant heterogeneity anymore. However, it is 57 388 58 ³⁸⁸ difficult to control the heterogeneity in the pooled outcomes from the studies which included both persistent AF 59 389 patients and paroxysmal AF patients. Due to insufficient studies, this SLR only tried to explore heterogeneity 60 3 90 resources for procedure time and ablation time by further excluding studies with obviously different patient

391 characteristics rather than conducting meta-regression analyses. The lack of definitions for some outcome measures 392 in the included studies could introduce measurement bias and further increase the heterogeneity in the pooled 393 evidence. In addition, this SLR doesn't have enough studies to explore the heterogeneity sources in other pooled 394 outcomes. For the same reason, this SLR only assessed the publication bias for RFCA procedure time and ablation 395 time. Given the fact that most of the included studies compared the STSF catheter with the ST catheter, the pooled 396 evidence regarding the comparisons between STSF with non-ST catheters was not robust enough. Thus, this SLR 397 didn't grade the pooled evidence because of the limitations discussed above. Future research with adequate quality 12 ³⁹⁸ is still needed to confirm the generated evidence from this SLR and further explore the potential clinical benefits of 13 399 using the STSF catheter to conduct RFCA for AF (such as preventing eschar and acute heart failure).

14400 In summary, this SLR demonstrated that STSF is superior to ST catheter by reducing procedure time, ablation ¹⁵401 time, fluoroscopy time, and irrigation fluid volume. Because both catheters use contact force technology which is a 16 17 402 key factor in determining ablation outcomes, it is not a surprise to see highly comparable acute procedure success 18⁴⁰³ of PVI and one-year post-ablation arrhythmia recurrence between STSF catheter and ST catheter from the pooled 19404 evidence. Due to the lack of sufficient and robust evidence to support other clinical benefits of the STSF catheter 20405 relative to other catheters, such as preventing eschar and acute heart failure, more future studies with appropriate ²¹406 study designs and sufficient sample size are needed in this field.

24⁴⁰⁷ 5. Figures

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26 ⁴⁰⁸ Figure 1. Literature search flowchart for identifying eligible studies (STSF: SMARTTOUCH® 27 409 SURROUNDFLOW; ST: THERMOCOOL SMARTTOUCH®; SF: SURROUNDFLOW; AF: Atrial fibrillation). 28410 Figure 2. Forest plot for the paired meta-analysis of the included studies for the difference in RFCA procedure ²⁹411 time (minutes) between STSF catheter and ST catheter (STSF: SMARTTOUCH® SURROUNDFLOW; ST: 30 31⁴¹² THERMOCOOL SMARTTOUCH®; AF: Atrial fibrillation; SD: Standard deviation; WMD: Weighted mean 32 413 difference; CI: Confidence interval).

33 4 1 4 Figure 3. Forest plot for the paired meta-analysis of the included studies for the difference in ablation time 34415 (minutes) between STSF catheter and ST catheter (STSF: SMARTTOUCH® SURROUNDFLOW; ST: ³⁵416 THERMOCOOL SMARTTOUCH®; AF: Atrial fibrillation; SD: Standard deviation; WMD: Weighted mean 36 37⁴¹⁰ 37 difference; CI: Confidence interval).

38418 Figure 4. Forest plot for the paired meta-analysis of the included studies for the difference in catheter irrigation 39419 fluid volume (mL) between STSF catheter and ST catheter for RFCA (STSF: SMARTTOUCH® 40 4 2 0 SURROUNDFLOW; ST: THERMOCOOL SMARTTOUCH®; AF: Atrial fibrillation; SD: Standard deviation; $41_{42}_{42}_{42}_{422}$ WMD: Weighted mean difference; CI: Confidence interval).

42 43⁴²² Figure 5. Forest plot for the paired meta-analysis of the included studies for the difference in fluoroscopy time 44 423 between STSF catheter and ST catheter for RFCA (STSF: SMARTTOUCH® SURROUNDFLOW; ST: THERMOCOOL SMARTTOUCH®; AF: Atrial fibrillation; SD: Standard deviation; WMD: Weighted mean 45 4 2 4 46 4 25 difference; CI: Confidence interval) 47 48 426

49 50 4 27 Acknowledgment

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56 57 431 **Conflict of Interest**

59432 Liang Tan and Wendong Chen are employed by contract research organizations that receive industry funds to 60 4 3 3 conduct health economics and outcomes research. Other authors declare that the research was conducted in the

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434 absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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10437 Availability of Data and Materials

Data sharing is not applicable to this article, as no datasets were generated or analyzed during the current study.

16440 **Author Contributions**

¹⁸441 Jianyong Li, Guifang Zhou, Yuegang Wang, and Xiaobo Huang formulated the research idea. Jianyong Li, 20 442 Guifang Zhou, Xinzhong Li, Senlin Huang, Yuegang Wang, Xiaobo Huang, Liang Tan, and Wendong Chen 21 4 4 3 developed the study protocol. Jianyong Li, Guifang Zhou, Xinzhong Li, Senlin Huang, Hairuo Lin, Shaopeng Lin, 22 4 4 4 and Liang Tan conducted the literature search, study quality assessment, data extraction, and evidence synthesis. 23 445 Jianyong Li, Guifang Zhou, Xinzhong Li, Senlin Huang, Xiaobo Huang, Yuegang Wang, and Wendong Chen ²⁴ 446 25 drafted the manuscript based on the study findings. All authors contributed to editorial changes in the manuscript. 26⁴⁴⁷ All authors read and approved the final manuscript.

28448 **Ethics Approval and Consent to Participate**

Not applicable.

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31 32 ⁵⁴²	[37] Shurrab M, Di Biase L, Briceno DF, et al. Impact of Contact Force Technology on Atrial Fibrillation Ablation:
33 543	A Meta-Analysis. J Am Heart Assoc 2015;4(9):e002476.
34 35 ⁵⁴⁴	[38] AlTurki A, Proietti R, Dawas A, et al. Catheter Ablation for Atrial Fibrillation in Heart Failure with Reduced
36 545	Ejection Fraction: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. BMC
37 546	Cardiovasc Disord 2019;19(1):1-13.
38 39 ⁵⁴⁷	[39] Waldo AL, Wilber DJ, Marchlinski FE, et al. Safety of the Open-Irrigated Ablation Catheter for
40 548 41 ₅₄₉	Radiofrequency Ablation: Safety Analysis from Six Clinical Studies. Pacing Clin Electrophysiol 2012;35(9):1081-1089.
42 43 550	[40] Huang HD, Waks JW, Contreras-Valdes FM, et al. Incidence and Risk Factors for Symptomatic Heart Failure
44 551	after Catheter Ablation of Atrial Fibrillation and Atrial Flutter. Europace 2016;18(4):521-530.
45 552 46	[41] Seiler J, Steven D, Roberts-Thomson KC, et al. The Effect of Open-Irrigated Radiofrequency Catheter
47 553	Ablation of Atrial Fibrillation on Left Atrial Pressure and B-Type Natriuretic Peptide. Pacing Clin
48 49 ⁵⁵⁴	Electrophysiol 2014;37(5):616-623.
50 555	[42] Matsuda Y, Masuda M, Sakio T, et al. Heart Rate Decrease after Atrial Fibrillation Catheter Ablation Predicts
51 556	Decompensated Heart Failure after the Procedure. Circ Rep 2022;4(10):461-468.
52 557	[43] Zambroski CH, Moser DK, Bhat G, et al. Impact of Symptom Prevalence and Symptom Burden on Quality of
⁵³ 558 54	Life in Patients with Heart Failure. Eur J Cardiovasc Nurs 2005;4(3):198-206.
54 55 559	[44] Keshishian J, Young J, Hill E, et al. Esophageal Injury Following Radiofrequency Ablation for Atrial
56 560	Fibrillation: Injury Classification. Gastroenterology & Hepatology. 2012;8(6):411-414.
57 561	[45] Li J, Li X, Huang S, et al. CO154 Differences in Clinical Utility Between Thermocool SmartTouch® Surround
⁵⁸ 562	Flow Catheter and Smarttouch or Surround Flow Catheter for Arial Fibrillation Ablation: A Systematic
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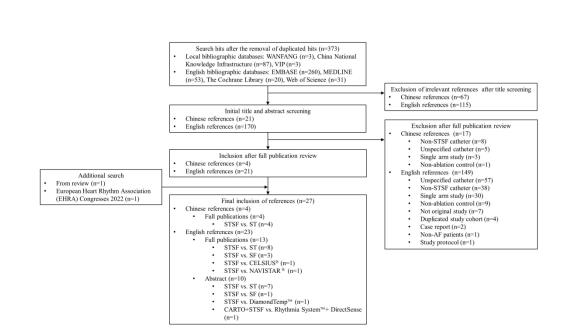


Figure 1. Literature search flowchart for identifying eligible studies (STSF: SMARTTOUCH® SURROUNDFLOW; ST: THERMOCOOL SMARTTOUCH®; SF: SURROUNDFLOW; AF: Atrial fibrillation).

327x185mm (300 x 300 DPI)

Study		STSF			ST		Before heterogeneity control	After heterogeneity control			
Study	Total	Mean	SD	Total	Mean	SD	Weighted Mean Difference	Weighted Mean Difference			
Unspecified AF											
Zhou 2021[13]	142	96.4	31.6	98	119.5	33.8	- 				
Lee 2019b [14]	39	168.0	34.0	32	199.0	42.0					
Lee 2019a [15]	66	160.0	37.0	32	199.0	42.0					
Solimene 2019 (Subgroup 2)[12]	151	125.0	73.0	81	144.0	44.0					
Maurer 2018[10]	75	131.3	33.7	35	133.0	42.0					
Plenge 2020 [11]	60	106.3	28.4	20	116.7	26.7					
Solimene 2019 (Subgroup 1)[12	162	120.0	72.0	96	129.0	44.0					
	695			394				-			
Heterogeneity: $I^2 = 62\%$, $\tau^2 = 92.0$	031, p =	0.01						21%, τ ² = 6.9084, p = 0.29			
							-40 -20 0 20 40	-40 -20 0 20			
Random effects model	meta-a	nalysis	result				WMD: -18.7, 95% CI: -27.6 to -9.7, p<0.001	WMD: -25.9, 95% CI: -33.0 to -18.8, p<0.0			
Paroxysmal AF							:				
Melby 2018[23]	71	114.0	30.0	102	114.0	24.0					
Duvtschaever 2019[24]	86	137.4	30.1	243	162.9	36.9					
Chopra 2018[25]	24	192.7	46.0	23	213.9	43.5					
enopia 2010()											
Random effects model	181			368							
Heterogeneity: $I^2 = 90\%$, $\tau^2 = 189$.	7783. p	< 0.01					-40 -20 0 20 40				
							-40 -20 0 20 40				
Random effects model	meta-a	nalysis	result				WMD: -14.7, 95% CI: -32.3 to 2.9, p=0.101				
Overall											
Random effects model	876			762			\$				
		< 0.01									
Heterogeneity: $I^2 = 76\%$, $\tau^2 = 111$.							-40 -20 0 20 40				

Figure 2. Forest plot for the paired meta-analysis of the included studies for the difference in RFCA procedure time (minutes) between STSF catheter and ST catheter (STSF: SMARTTOUCH® SURROUNDFLOW; ST: THERMOCOOL SMARTTOUCH®; AF: Atrial fibrillation; SD: Standard deviation; WMD: Weighted mean difference; CI: Confidence interval).

303x155mm (300 x 300 DPI)

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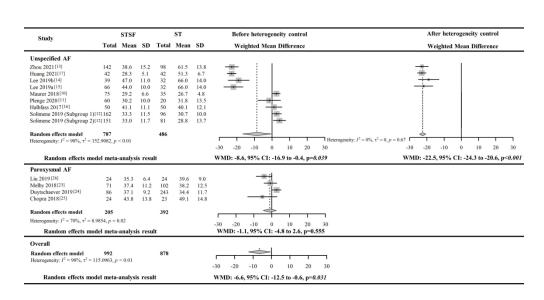


Figure 3. Forest plot for the paired meta-analysis of the included studies for the difference in ablation time (minutes) between STSF catheter and ST catheter (STSF: SMARTTOUCH® SURROUNDFLOW; ST: THERMOCOOL SMARTTOUCH®; AF: Atrial fibrillation; SD: Standard deviation; WMD: Weighted mean difference; CI: Confidence interval).

311x163mm (300 x 300 DPI)

Study	STSF						· .	Weighted Mean Difference				
Study	Total	Mean	SD	Total	Mean	SD		Weighten I	vican Di	nerence		
Unspecified AF												
Maurer 2018[10]	75	265.5	64.4	35	539.6	118.2		: •	1			
Plenge 2020 [11]	60	241.4	79.6	20	540.3	229.5			.			
Solimene 2019 (Subgroup 1)	[12]162	701.0	287.0	96	1105.0	573.0						
Solimene 2019 (Subgroup 2)	[12]151	836.0	503.0	81	1732.0	664.0		- [
Random effects model Heterogeneity: $I^2 = 94\%$, $\tau^2 = 7$	448	n < 0.01		232				\sim	-		_	
Heterogeneity: $I = 94\%$, $\tau = 7$	6833.3378,	p < 0.01					-1000	-500	0	500	1000	
Random effects mode	l meta-ar	nalysis r	esult			WMD: -461.4, 95% CI: -739.2 to -183.6, p=0.001						
Paroxysmal AF												
Melby 2018[23]	71	563.0	168.0	102	1145.0	375.0		÷.	1			
Duytschaever 2019[24]	86	785.3	356.0	243	1255.6	469.3		÷				
Chopra 2018 [25]	24	697.3	299.3	23	1277.0	315.8	-					
Random effects model	181			368								
				308					_			
Heterogeneity: $I^2 = 38\%$, $\tau^2 = 2$	2229.0153,	p = 0.20					-1000	-500	0	500	1000	
Random effects mode	l meta-ar	nalysis r	esult			v		8.6, 95% C				
Overall											-	
Random effects model	629			600				$\dot{\langle}$	1			
Heterogeneity: $I^2 = 94\%$, $\tau^2 = 3$		p < 0.01		500				Ť		1		
		, p . 0.01					-1000	-500	0	500	1000	
Random effects model meta-analysis result WMD: -492.7, 95% CI: -646.1 to -339.3, p<0.001												

Figure 4. Forest plot for the paired meta-analysis of the included studies for the difference in catheter irrigation fluid volume (mL) between STSF catheter and ST catheter for RFCA (STSF: SMARTTOUCH® SURROUNDFLOW; ST: THERMOCOOL SMARTTOUCH®; AF: Atrial fibrillation; SD: Standard deviation; WMD: Weighted mean difference; CI: Confidence interval).

203x140mm (300 x 300 DPI)

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Study	STSF ST						Weished Many Difference
Study	Total	Mean	SD	Total	Mean	SD	Weighted Mean Difference
Unspecified AF							
Maurer 2018 [10]	75	14.0	6.0	35	13.5	6.6	
Zhou 2021[13]	142	15.3	3.3	98	16.9	3.6	
Plenge 2020[11]	60	16.0	6.7	20	13.8	5.7	· · · · ·
Solimene 2019 (Subgroup 1)	[12] 162	4.3	5.9	96	9.0	4.8	:
Solimene 2019 (Subgroup 2)		6.3	7.6	81	9.0	6.9	
Random effects model	590			330			
Heterogeneity: $I^2 = 86\%$, $\tau^2 = 5$		0.01		000			
	,, , , , , , , , , , , , , , , , , , ,						-6 -4 -2 0 2 4 6
Random effects mode	l meta-ar	alysis r	esult				WMD: -1.5, 95% CI: -3.8 to 0.8, p=0.201
Paroxysmal AF							
Zhang 2020[27]	34	11.3	2.9	34	12.3	3.3	
Liu 2019 [26]	24	7.8	3.1	24	11.2	6.3	
Melby 2018 [23]	71	3.1	4.4	102	4.7	2.7	
Chopra 2018[25]	24	8.5	3.9	23	8.7	4.6	
Random effects model	153			183			\diamond
Heterogeneity: $I^2 = 8\%$, $\tau^2 < 0$.0001, <i>p</i> =	0.35					
							-6 -4 -2 0 2 4 6
Dandam offects mode	l meta-ar	alysis r	esult				WMD: -1.4, 95% CI: -2.2 to -0.6, p<0.001
Random effects mode							
Overall							
Overall	743			513			
Overall Random effects model	/	0.01		513			
	/	0.01		513			

Figure 5. Forest plot for the paired meta-analysis of the included studies for the difference in fluoroscopy time between STSF catheter and ST catheter for RFCA (STSF: SMARTTOUCH® SURROUNDFLOW; ST: THERMOCOOL SMARTTOUCH®; AF: Atrial fibrillation; SD: Standard deviation; WMD: Weighted mean difference; CI: Confidence interval)

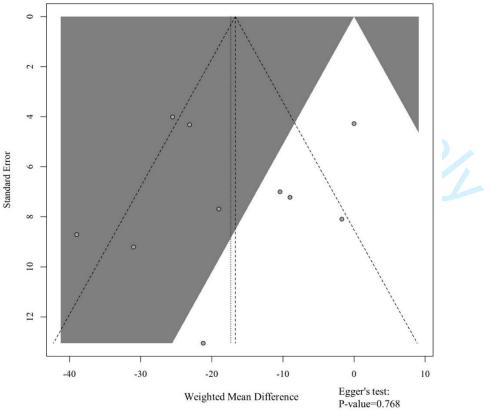
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Supplementary Figures

Supplementary Figure 1. Forest plot of the leave-one-out sensitivity analysis for pooled difference in RFCA procedure time (minutes) between STSF catheter and ST catheter (WMD: Weighted mean difference; CI: Confidence interval).

		WAD			Pooled estimation after excluding one study						
Excluded study		WMD		,	Point estimation	95% CI	P-value	I ²			
Omitting Zhou 2021 [13]		. 1			-16.6	[-25.5; -7.7]	< 0.001	76%			
Omitting Lee 2019b [14]		R.			-16.1	[-24.4; -7.9]	< 0.001	77%			
Omitting Lee 2019a[15]					-15.2	[-22.8; -7.7]	< 0.001	73%			
Omitting Solimene 2019 (Subgroup 2)[12]					-17.2	[-26.0; -8.4]	< 0.001	78%			
Omitting Maurer 2018[10]					-18.9	[-27.1; -10.8]	< 0.001	76%			
Omitting Plenge 2020 [11]					-18.2	[-26.9; -9.5]	< 0.001	78%			
Omitting Solimene 2019 (Subgroup 1)[12]					-18.3	[-27.0; -9.7]	< 0.001	77%			
Omitting Melby 2018 [23]					-19.9	[-27.0; -12.8]	< 0.001	55%			
Omitting Duytschaever 2019 [24]					-16.2	[-24.9; -7.5]	< 0.001	74%			
Omitting Chopra 2018[25]					-17.1	[-25.6; -8.7]	< 0.001	78%			
Random effects model				7	-17.4	[-25.3; -9.4]	< 0.001	76%			
	-20 -10	0	10	20							

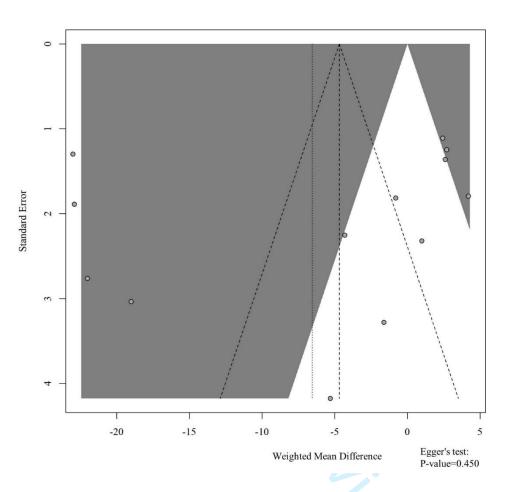
Supplementary Figure 2. Illustrated publication bias analysis for the included studies comparing STSF catheter with ST catheter for RFCA procedure time (minutes).



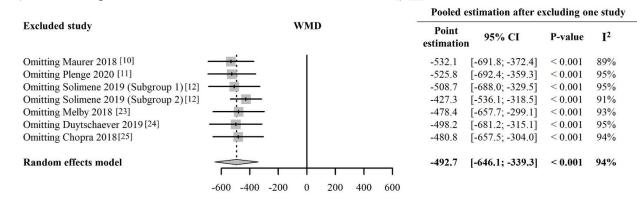
Supplementary Figure 3. Forest plot of the leave-one-out sensitivity analysis for pooled difference in ablation time (minutes) between STSF catheter and ST catheter (WMD: Weighted mean difference; CI: Confidence interval).

	WAID	Pooled estimation after excluding one study					
Excluded study	WMD	Point estimatio	n 95% CI	P-value	I ²		
Omitting Zhou 2021 ^[13]		-5.2	[-10.9; 0.6]	0.081	97%		
Omitting Huang 2021 [17]		-5.1	[-10.9; 0.6]	0.081	96%		
Omitting Lee 2019b [14]		-5.6	[-11.7; 0.6]	0.075	98%		
Omitting Lee 2019a [15]		-5.3	[-11.2; 0.6]	0.079	98%		
Omitting Maurer 2018 [10]		-7.3	[-13.6; -1.0]	0.022	98%		
Omitting Plenge 2020 [11]		-7.0	[-13.4; -0.5]	0.033	98%		
Omitting Halbfass 2017 [18]		-7.2	[-13.5; -0.8]	0.026	98%		
Omitting Solimene 2019 (Subgroup 1)[12] -		-7.3	[-13.6; -1.1]	0.022	98%		
Omitting Solimene 2019 (Subgroup 2)[12] -		-7.5	[-13.7; -1.3]	0.018	98%		
Omitting Liu 2019 [26]		-6.7	[-13.2; -0.3]	0.041	98%		
Omitting Melby 2018 [23]		-7.0	[-13.5; -0.6]	0.031	98%		
Omitting Duytschaever 2019 [24]		-7.4	[-13.6; -1.1]	0.022	98%		
Omitting Chopra 2018 [25]		-6.7	[-13.1; -0.2]	0.043	98%		
Random effects model		-6.6	[-12.5; -0.6]	0.031	98%		
	-10 -5 0 5 10						

Supplementary Figure 4. Illustrated publication bias analysis for the included studies comparing STSF catheter with ST catheter for ablation time (minutes).



Supplementary Figure 5. Forest plot of the leave-one-out sensitivity analysis for pooled difference in irrigation fluid volume (mL) during RFCA between STSF catheter and ST catheter (WMD: Weighted mean difference; CI: Confidence interval).



Supplementary Figure 6. Forest plot of the sensitivity analysis for pooled difference in fluoroscopy time (minutes) during RFCA between STSF and ST (WMD: Weighted mean difference; CI: Confidence interval).

Excluded study	WMD	Point estimation	95% CI	P-value	I ²
Omitting Maurer 2018 ^[10]	<u> </u>	-1.8	[-3.1; -0.5]	0.007	779
Omitting Zhou 2021 [13]	i	-1.5	[-3.0; -0.1]	0.042	799
Omitting Plenge 2020[11]		-1.9	[-3.1; -0.8]	0.001	749
Omitting Solimene 2019 (Subgroup 1)[12]		-1.4	[-1.9; -0.8]	< 0.001	45%
Omitting Solimene 2019 (Subgroup 2)[12]		-1.4	[-2.8; -0.0]	0.050	799
Omitting Zhang 2020 [27]		-1.6	[-3.1; -0.2]	0.027	789
Omitting Liu 2019 [26]		-1.4	[-2.7; -0.0]	0.044	799
Omitting Melby 2018 [23]		-1.5	[-3.0; -0.1]	0.041	799
Omitting Chopra 2018 [25]		-1.7	[-3.1; -0.3]	0.014	789
Random effects model		-1.6	[-2.8; -0.3]	0.014	779
	-3 -2 -1 0 1 2	3			

Supplementary Figure 7. Forest plot for the paired meta-analysis of the included studies comparing STSF vs. ST for acute procedural success of PVI (STSF: SMARTTOUCH[®] SURROUNDFLOW; ST: THERMOCOOL SMARTTOUCH[®]; AF: Atrial fibrillation; RR: Rate ratio; CI: Confidence interval).

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ST

Events

Total

42

Rate Ratio

STSF

Events Total

2	
3 4 5 6	Study
7	Unspecified AF
8 9 10 11 12 13 14 15	Maurer 2018 [10] Huang 2021 [17] Halbfass 2017 [16] Lee 2019b [14] Lee 2019a [15] Solimene 2019 (Su
16 17 18	Random effects m Heterogeneity: $I^2 = 0$
19 20	Random effect
21	Paroxysmal AF
22 23 24	Liu 2019 [26] Dhillon 2019 [28]
25 26 27	Random effects m Heterogeneity: $I^2 = 7$
28	Random effect
29 30	Overall
31	Random effects me
32 33	Heterogeneity: $I^2 = 0^6$
34	Random effect
35	
36 37	
38	
39 40	
40 41	
42	
43 44	
45	
46 47	
47 48	
49	
50 51	
52	Supplementary
53 54 55 56 57	comparing STSF recurrence (STSF SMARTTOUCH
58 59	F
60	

	64 66	31	32			
Solimene 2019 (Subgroup 1)[12] 1	53 162	94	96			
Solimene 2019 (Subgroup 2)[12] 1	39 151	77	81			
Random effects model	585		368	\$		
Heterogeneity: $I^2 = 0\%$, $\tau^2 = 0$, $p = 0$.	.95					
				0.75 1	1.5	2.5
Random effects model meta	-analysis res	ult		RR: 0.993, 95%	CI: 0.974 to 1.01	3, p=0.504
Paroxysmal AF						
Liu 2019 [26] 2	24 24	24	24			
Dhillon 2019 [28]	34 50	24	50			_
Random effects model	74		74			
Heterogeneity: $I^2 = 73\%$, $\tau^2 = 0.0443$			74			1
, j	71			0.75 1	1.5	2.5
Random effects model meta-	-analysis res	ult		RR: 1.141, 95%	CI: 0.819 to 1.58	89, p=0.435
Overall						
Random effects model	659		442			
Heterogeneity: $I^2 = 0\%$, $\tau^2 < 0.0001$, I	p = 0.68				1	1
Den lana (fra ta ana dalara ta		.14		0.75 1	1.5	2.5
Random effects model meta	-analysis res	un		RR: 0.995, 95%		4, p=0.392
pplementary Figure 8. For mparing STSF catheter with currence (STSF: SMARTT MARTTOUCH [®] ; AF: Atria	th ST cathe OUCH [®] S	ter for URRO	one-yea UNDFL	r post-ablation ca OW; ST: THERN	rdiac arrhythm 4OCOOL	
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Study	STSF		ST		Data Datia
Study	Events	Total	Events	Total	Rate Ratio
Unspecified AF					
Maurer 2018 [10]	15	74	9	35	
Zhou 2021 [13]	7	142	20	98	——————————————————————————————————————
Huang 2021 [17]	0	42	1	42	
Stabile 2020 (Subgroup 1)[12] 21	140	4	89	:
Stabile 2020 (Subgroup 2)[12] 14	149	9	74	
Random effects model		547		338	
Heterogeneity: $I^2 = 74\%$, $\tau^2 = 0$.	.7752, p	< 0.01			
					0.1 0.5 1 2 10
Random effects model meta	n-analysis	s result			RR: 0.761, 95% CI: 0.301 to 1.925, p=0.50
Paroxysmal AF					
Dhillon 2019 [28]	11	50	18	50	
					1 1 1
					0.5 1 2
					0.5 1 2 RR: 0.611, 95% CI: 0.322 to 1.158, p=0.1
Overall		597		388	
Overall Random effects model		597		388	
Overall Random effects model		597		388	
Overall Random effects model Heterogeneity: $I^2 = 68\%$, $\tau^2 = 0$. Random effects model meta	5323, p <	597 < 0.01		388	RR: 0.611, 95% CI: 0.322 to 1.158, p=0.12

Supplementary Figure 9. Forest plot of the leave-one-out sensitivity analysis for pooled RR for one-year post-ablation cardiac arrhythmia recurrence between STSF catheter and ST catheter (RR: Rate ratio; CI: Confidence interval).

Pooled estimation after excluding one study RR **Excluded study** Point 95% CI I² **P-value** estimation Omitting Maurer 2018^[10] 0.476 74% 0.714 [0.283; 1.803] Omitting Zhou 2021 [13] 0.929 [0.501; 1.723] 0.815 50% 74% Omitting Huang 2021 [17] 0.755 [0.354; 1.609] 0.466 [0.342; 0.901] Omitting Stabile 2020 (Subgroup 1)[12] 0.555 0.017 30% Omitting Stabile 2020 (Subgroup 2)[12] 0.718 [0.286: 1.803] 0.480 74% Omitting Dhillon 2019 [28] [0.301; 1.925] 0.564 74% 0.761 0.384 **Random effects model** 0.727 [0.355; 1.490] 68% Г 0.5 2 1

Supplementary Figure 10. Forest plot for the paired meta-analysis of the included studies comparing STSF catheter with ST catheter for the risk of overall complications related to RFCA (STSF: SMARTTOUCH[®] SURROUNDFLOW; ST: THERMOCOOL SMARTTOUCH[®]; AF: Atrial fibrillation; RR: Rate ratio; CI: Confidence interval).

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Study	ST	ſSF	S	T		
Study	Events	Total	Events	Total	Rate Ratio	
Unspecified AF					L	
Huang 2021 [17]	0	42	0	42		_
Plenge 2020 [11]	1	60	1	20		
Halbfass 2017 [16]	2	50	0	50		
Lee 2019b [14]	0	39	0	32		
Random effects model		191		144		
Heterogeneity: $I^2 = 0\%$, $\tau^2 =$	= 0.1629, _J	p = 0.63			0.001 0.01 0.1 1 10 100	
Random effects mod	al mota-a	nolveie	rocult		RR: 1.113, 95% CI: 0.166 to 7.440, p=	A (
	er meta-a	inary 515	result		KK. 1.113, 3570 CI. 0.100 to 7.440, p-	0.2
Paroxysmal AF						
Liu 2019 [26]	0	24	0	24		
Melby 2018 [23]	0	71	1	102	_	
Dhillon 2019 [28]	0	50	3	50		
Duytschaever 2019 [24]	3	86	9	243		
Random effects model		231		419		
Heterogeneity: $I^2 = 0\%$, τ^2	= 0, p = 0.	.71				
					0.001 0.1 1 10	10
Random effects mod	el meta-a	nalysis	result		RR: 0.673, 95% CI: 0.226 to 2.006, p=	:0.4
Overall						
Random effects model		422		563		
Heterogeneity: $I^2 = 0\%$, $\tau^2 =$	=0, p=0.	85			0.001 0.1 1 10	10
Random effects mod	al moto a	nalusia	waanit			
Kandom enects mou	el meta-a	marysis	result		RR: 0.766, 95% CI: 0.299 to 1.959, p=	0.:

Supplementary Figure 11. Forest plot for the paired meta-analysis of the included studies comparing STSF catheter with ST catheter for foley catheter use (STSF: SMARTTOUCH[®] SURROUNDFLOW; ST: THERMOCOOL SMARTTOUCH[®]; RR: Rate ratio; CI: Confidence interval).

	STS	SF	ST					
Study	Events	Total	Events	Total	Rate Ratio	RR	95%-CI	P-value
Melby 2018 [23]	31	71	86	102	- <u></u>	0.518	[0.393; 0.684]	
Duytschaever 2019[24]	10	86	63	243		0.448	[0.241; 0.833]	
Random effects model Heterogeneity: $I^2 = 0\%$, τ^2	= 0, <i>p</i> = 0.6	1 57 57		345		0.506	[0.393; 0.652]	<0.001
					0.5 1 2			

Supplementary Figure 12. Forest plot for the paired meta-analysis of the included studies comparing STSF catheter with SF catheter for acute procedure success of PVI (STSF: SMARTTOUCH[®] SURROUNDFLOW; SF: SURROUNDFLOW; AF: Atrial fibrillation; RR: Rate ratio; CI: Confidence interval).

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Study		SF	SF		Rate Ratio
	Events	Total	Events	Total	
Unspecified AF					
Dugo 2016 [29]	26	26	26	26	
5					
					0.9 1 1.1
					RR: 1.000, 95% CI: 0.928 to 1.078, p=1.000
Paroxysmal AF					
Uetake 2020 [31]	298	298	97	97	
					0.9 1 1.1
·					RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000
Overall					
Random effects model		324		123	\rightarrow
Heterogeneity: $I^2 = 0\%$, $\tau^2 =$	0, p = 1.0				
					0.9 1 1.1
Random effects model n	neta-analy	sis resul	t		RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000
			IV.		

Supplementary Figure 13. Forest plot for the paired meta-analysis of the included studies comparing STSF catheter with SF catheter for one-year post-ablation arrhythmia recurrence (STSF: SMARTTOUCH® SURROUNDFLOW; SF: SURROUNDFLOW; AF: Atrial fibrillation; RR: Rate ratio; CI: Confidence interval).

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Study	ST	SF	S	F	Rate Ratio	
Study	Events	Total	Events	Total	Kate Katio	
Paroxysmal AF						
Uetake 2020 [31]	65	298	42	97		
					0.5 1 2	
					RR: 0.504, 95% CI: 0.368 to 0.689, p<0.0	
Persistent AF						
Takamiya 2020 [32]	11	74	22	74	I	
Tukumiyu 2020 [0-]	11	/1		/ 1	T1	
					0.5 1 2	0.24
o "					RR: 0.500, 95% CI: 0.262 to 0.956, p=0.0	930
Overall Random effects model		372		171	<u> </u>	
Heterogeneity: $I^2 = 0\%$, $\tau^2 =$	= 0, p = 0.			1/1		
					0.5 1 2	
Random effects model n	ieta-analy	sis result			RR: 0.503, 95% CI: 0.379 to 0.667, p<0.	001

Supplementary Figure 14. Forest plot for the paired meta-analysis of the included studies comparing STSF catheter with SF catheter for the risk of overall complications related to RFCA (STSF: SMARTTOUCH[®] SURROUNDFLOW; SF: SURROUNDFLOW; AF: Atrial fibrillation; RR: Rate ratio; CI: Confidence interval).

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Study	STSF		S	SF		Rate Ratio				
Study	Events	Total	Events	Total			Kate Katio			
Unspecified AF										
Gonna 2017 [30]	0	100	2	100				-		
Dugo 2016 [29]	1	26	0	26						
							:			
Random effects model		126		126						
Heterogeneity: $I^2 = 32\%$, τ^2	= 1.1811,	p = 0.22			1	1	1	1	1	
					0.01	0.1	1	10	100	
Random effects model me	eta-analysis	s result			RR:	0.745, 959	% CI: 0.052 to	10.574, p=0	.828	
Persistent AF										
Takamiya 2020 [32]	4	74	2	74						
ý						1		1		
					0.01	0.1	0.5 1 2	10	100	
					RR:	2.000, 959	% CI: 0.378 to 2	10.587, p=0	.415	
Overall										
		200		200				-		
Random effects model						1		1		
Random effects model Heterogeneity: $I^2 = 0\%$, $\tau^2 < 0\%$	< 0.0001, p	= 0.37								
Random effects model Heterogeneity: $I^2 = 0\%$, $\tau^2 < 10\%$	< 0.0001, p	= 0.37			0.01	0.1	1	10	100	

Supplementary Figure 15. Forest plot of the leave-one-out sensitivity analysis for pooled RR for the risk of overall complications related to RFCA between STSF catheter and SF catheter (RR: Rate ratio; CI: Confidence interval).

					Pooled est	imation after exc	luding one	e study	
Excluded study		RR			Point estimation	95% CI	P-value	I ²	-
Omitting Gonna 2017 [30]					2.185	[0.501; 9.537]	0.299	0%	
Omitting Dugo 2016 [29]	-			_	0.906	[0.106; 7.730]	0.928	41%	
Omitting Takamiya 2020 [32]				_	0.745	[0.052; 10.574]	0.828	32%	
Random effects model	(1		1.381	[0.367; 5.193]	0.633	0%	
	0.1	0.5 1	2	10					

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Suppler Reference ID	Region	Publication type	Publication language	Study design	n extracted informati Patient inclusion and exclusion criteria	Catheter comparison and sample size	Patient characterstics_	Main outcomes
Halbfass 2017 [16]	Germany	Full text	English	Prospective cohort study	Inclusion criteria: Patients with symptomatic, drug- refractory paroxysmal or persistent atrial fibrillation (AF) who underwent left atrial radiofrequency (RF) catheter ablation and post-procedural esophagogastroduodeno scopy (EGD) Exclusion criteria: Unspecified.	STSF (n=50) vs. ST (n=50)	Demographics Structure • Mean age: STSF Structure • Mean age: STSF Structure • Male: STSF vs. Structure • Male: STSF vs. Structure • BMI: STSF vs. Structure • BMI: STSF vs. Structure • BMI: STSF vs. Structure • Paroxysmal Affairs F vs. ST (44% vs. 38%, p=0.05); • Left ventricularies from fraction: STSF vs. Structure • CHA ₂ DS ₂ VASE Score: STSF vs. ST (2.3±1.5 Structure • Coronary arter Edison • Hypertension: STSF vs. ST (90% vs. 98%, p=0.20); • Coronary arter Edison • Stroke/transiene Bischemic attack: STSF vs. ST (100 vs. 3% , p=1.00). Stroke/transiene bischemic attack: STSF vs. ST (100 vs. 3% , p=1.00).	Procedural characteristics • Ablation time: STSF vs. ST (41.1±11.1 vs. 40.1±12.1 minutes, p=0.66); Clinical outcomes • Acute procedure success rat STSF vs. ST (100% vs. 100% • Any complications: STSF v ST (4% vs. 0%, p=0.49); • Cardiac tamponade: STSF v ST (2% vs. 0%); • Bleeding: STSF vs. ST (2% vs. 0%).
Horiuchi 2017 [18]	Japan	Abstract	English	Randomized controlled study	Inclusion criteria: Atrial fibrillation patients undergoing circumferential pulmonary vein isolation. Exclusion criteria: Unspecified.	STSF (n=20) vs. ST (n=20)	Pooled information of we groups Demographics • Mean age: 60±11 years; Clinical characteristics • Paroxysmal AF: 47.5%.	 Procedural characteristics Median radiofrequency time from superior to anterior sites STSF vs. ST (9 vs. 22 second p<0.01); Median radiofrequency time at inferior and posterior sites: STSF vs. ST (9 vs. 8 seconds p=NS);

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Ullah 2017 [19]	United Kingdom	Full text	English	Prospective cohort study	Inclusion criteria: Patients undergoing their first catheter ablation procedure for atrial fibrillation (AF)	STSF (n=10) vs. ST (n=30)	io/bmjopen-2023-075579 on 17 October 2023-075579 on 17 October 2023-075799 on 17 October 20	 There was no difference between the two groups in mean contact force at each sites (anterior, anterosuper anteroinferior, inferior, posterosuperior site); Total number of residual conduction gaps: STSF vs (1.0±1.1 vs. 0.9±1.1, p=N: Procedural characteristics Median catheter tip temperature at the start of energy delivery: STSF vs. (28 vs. 36 °C, p<0.005);
					Exclusion criteria: Unspecified.	с. 24 0	• Paroxysmal AF3 $(50 \% \text{ vs. } 50\%, p)$ • Duration of persistent AF: STSF vs. ST (11±3 vs. 0± (11 ± 3) months, p=0.13); • Left atrial diameter STSF vs. ST (4.1±0.8 vs. 44±00 cm, p=0.17); • CHA ₂ DS ₂ VASt score: STSF vs. ST (1.5±0.8 vs. 1.4±1.0, p=0.61).	 Median impedance at sta energy delivery: STSF vs. (154 vs. 181 Ω, p<0.005); Median minimum cathel temperature during RF delivery: STSF vs. ST (25 35 °C, p<0.005); Median time to reach minimum catheter tip temperature: STSF vs. ST vs. 1.2 seconds, p<0.005) Median maximum cathet tip temperature during RF delivery: STSF vs. ST (25 41 °C, p<0.005); Median time to reach maximum catheter tip temperature: STSF vs. ST vs. 14.9 seconds, p<0.005 Median time to reach maximum ablation power STSF vs. ST (0.6 vs. 8.1 seconds, p<0.005).
Chopra 2018 [25]	United States	Full text	English	Retrospectiv e study	Inclusion criteria: Patients aged between 18 and 81 years who had undergone a radiofrequency ablation procedure for the indication of	STSF (n=24) vs. ST (n=23)	 Pooled information of wo groups Clinical characteristics Left atrial diameter: 4.2±7.5 mm; Left ventricular ejection fraction: 57.8%±7%; 6 CHADS VASc Score 2.4±1.4. 	 Procedural characteristics Procedure time: STSF v (192.7±46.6 vs. 213.9±43 minutes, p=0.11); Ablation time: STSF vs (43.8±13.8 vs. 49.1±14.8 minutes, p=0.18);

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$ \begin{array}{r} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ 12 \\ 13 \\ 14 \\ 15 \\ 16 \\ 17 \\ 18 \\ 19 \\ 20 \\ 21 \\ 22 \\ 23 \\ 24 \\ 25 \\ 26 \\ 27 \\ 28 \\ 29 \\ 30 \\ 31 \\ 32 \\ 33 \\ 34 \\ 35 \\ 36 \\ 37 \\ 38 \\ 39 \\ 40 \\ 41 \\ \end{array} $	Maurer 2018 [10]	Germany	Full text	English	Prospective cohort study	paroxysmal AF at OhioHealth Riverside Methodist Hospital, Columbus, Ohio, USA, from May 1, 2017, to June 1, 2018. Exclusion criteria: Unspecified. Inclusion criteria: Patients with symptomatic, drug- refractory paroxysmal, or short-term persistent AF (< 3 months in duration). Exclusion criteria: 1. Prior pulmonary vein isolation or left atrial surgery; 2. A left atrial (LA) diameter > 60 mm; 3. Severe valvular heart disease or contraindications to post-interventional oral anticoagulation.	STSF (n=75) vs. ST (n=35)	Clinical characteristics Paroxysmal AHISTSF vs. ST (45.2±6.6 vs. 44.29±6 mm); Male: STSF vs. ST (5.3±4.3 kg/m ²); Clinical characteristics Paroxysmal AHISTSF vs. ST (52% vs. 43%); Median CHADE Score: STSF vs. ST (45.2±6.6 vs. 44.29±6 mm); Median CHADE Score: STSF vs. ST (1 vs. 1); tech Comorbidities no. 14 Comorbidities STSF vs. ST (5.3% vs. 71.4%); Competitive heart failure: STSF vs. ST (61.3% vs. 71.4%); Competitive heart failure: STSF vs. ST (9.3% vs. 11.4%); Stroke/transient ischemic attack: STSF vs. ST (4% vs. 44.3%).	• Fluoroscopy time: STSF vs. ST (511.8±231.8 vs. 523.6±277.4 seconds, p =0.39); • Total fluid: STSF vs. ST (2,288.8±725.8 vs. 3,105±803 mL, p <0.001); • Fluid via ablation catheter: STSF vs. ST (697.3±299.3 vs. 1277±315.8 mL, p <0.001); • Fluid from sources other than ablation catheter: STSF vs. ST (1591±583.6 vs. 1828±689 mL, p =0.21); • Post-RFA Furosemide use (0% vs. 39%; p =0.0006). Procedural characteristics • Procedural characteristics • Procedure time: STSF vs. ST (131.3±33.7 vs. 133.0±42 minutes, p =0.995); • Ablation time: STSF vs. ST (1751±394.0 vs. 1604.6±287.8 seconds, p =0.201); • Fluoroscopy time: STSF vs. ST (14±6 vs. 13.5±6.6 minutes, p =0.559); • Total fluid: STSF vs. ST (265.5±64.4 vs. 539.6±118.2 mL, p <0.001); Clinical outcomes • Acute procedure success rate: STSF vs. ST (100% vs. 100%); • 12-month arrhythmia recurrence rate: STSF vs. ST (20.3% vs. 25.7%); • Audible steam pop: STSF vs. ST (0% vs. 0%).
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Melby 2018 [23]	Unspecifi ed	Abstract	English	Retrospectiv e study	Inclusion criteria: Paroxysmal AF patients undergoing first-time ablation, guided by CARTO VISITAG TM Module. Exclusion criteria: Unspecified.	STSF (n=71) vs. ST (n=102)	Demographics . Demographics . Mean age: STSE vs. ST (60 ± 10 vs. 61 ± 9 years, $p=0.74$; Clinical characteristics . Left ventricular ejection fraction: STSF vs. ST (60.2 ± 7.6 vs. $59.5\pm7.9\%$, $p=0.56$; CHADS VASC Sere: STSF vs. ST (1.62 ± 1.4 vs. ated to the state of	Procedural characteristics • Procedure time: STSF vs. (1.9 \pm 0.5 vs. 1.9 \pm 0.4 hours, p=0.77); • Ablation time: STSF vs. S (37.4 \pm 11.2 vs. 38.2 \pm 12.5 minutes, $p=0.74$); • Fluoroscopy time: STSF ST (3.1 \pm 4.4 vs. 4.7 \pm 2.7 minutes, $p<0.001$); • Fluoroscopy dose: STSF ST (12.4 \pm 16.7 vs. 27.3 \pm 18 mGy, $p<0.001$); • Total fluid: STSF vs. ST (1505 \pm 440 vs. 2353 \pm 605 n p<0.001); • Fluid via ablation cathete STSF vs. ST (563 \pm 168 vs. 1145 \pm 375 mL, $p<0.001$); • Foley catheter usage (%): STSF vs. ST (43.7% vs. 84.3%, $p<0.001$); • Clinical outcomes • Any complications: STSF ST (0% vs. 1%); • Cerebrovascular accident STSF vs. ST (0% vs. 1%).
Dhillon 2019 [28]	United Kingdom	Full text	English	Prospective cohort study	Inclusion criteria:	STSF (n=50) vs. ST (n=50)	Demographics S : • Mean age: STS H vs. S T (60.1±11.8 vs. 5H 9±10.8 years, p=0.915); • Male: STSF vs. S T (60.1±11.8 vs. 5H 9±10.8 years, p=0.915); • Male: STSF vs. S T (60.1±11.8 vs. 5H 9±10.8 years, p=0.915); • Male: STSF vs. S T (60.1±11.8 vs. 5H 9±10.8 years, p=0.0% vs. 4 5 Clinical character stice • Median duration of a F: STSF vs. ST (24 vs. 42 morths, p=0.057); • Left atrial diameter: 5 TSF vs. ST (37.6±5 vs. 38.7±6 mm, p=0.145); • CHA ₂ DS ₂ VASc Sche: STSF vs. ST (1.3±1.2 vs. 1 6 3±1.6,	Procedural characteristics • Mean procedure time: ST vs. ST (156 vs. 199 minute p<0.001); • Mean ablation time: STS ST (27.2 vs. 43.2 minutes, p<0.001); • Mean left wide antral circumferential ablation T STSF vs. ST (29.5 vs. 38.5 minutes, p <0.001); • Mean right wide antral circumferential ablation T STSF vs. ST (32 vs. 38.5 minutes, p =0.001);

Duytschae Europe Abstract English Prospective cohort study Inclusion criteria: Patients underwent point-by-point paroxysmal atrial STSF (n=86) vs. STSF (n=243) Not reported Not reported </th <th></th> <th>BMJ Open</th> <th>6/bmjopen-2023- cted by copyrigh</th> <th></th>		BMJ Open	6/bmjopen-2023- cted by copyrigh	
	ver 2019	cohort study Patients underwent point-by-point paroxysmal atrial fibrillation ablations across 17 European centers in the VISTAX study. Exclusion criteria:	Comorbidities • Hypertension: STSF s. ST (38% vs. 34%, p) 0.8 (3); • Diabetes Mellines: STSF vs. ST (12% vs. 6%, p=0.48); • Ischemic HeartDisecse: STSF vs. ST (4% vs. 265 relignement Superieur (ABES), . STSF (n=86) vs. Not reported ST (n=243) STSF (n=243)	 12-month AF/AT recurrence rate: STSF vs. ST (6% vs. 34%); Any complications: STSF vs. ST (0% vs. 6%); Pericarditis: STSF vs. ST (0% vs. 4%); Femoral venous hematoma STSF vs. ST (0% vs. 2%). Procedural characteristics Procedural characteristics Procedure time: STSF vs. ST (137.4±30.1 vs. 162.9±36.9 minutes); Ablation time: STSF vs. ST (37.1±9.23 vs. 34.4±11.73 minutes); Fluid via ablation catheter: STSF vs. ST (785.3±356.0 v 1,255.6±469.3 mL); Foley catheter usage (%): STSF vs. ST (11.6% vs 25.9%); Clinical outcomes Any complications: STSF vs.
Goldstein United Abstract English Retrospectiv Inclusion criteria: STSF (n=1,445) Demographics Age group ≥70°STS vs. ST • Age group ≥70°STS vs. ST (n=1,766) • Age group ≥70°STS vs. ST (n=1,766) • Clinical characteristics Not reported [20] V V Patients with a primary diagnosis of AF (≥18 years) who underwent radiofrequency ablation between 09/01/2016– • Paroxysmal AF: STSF vs. ST • Clinical characteristics • Paroxysmal AF: STSF vs. ST (331/2018, identified from the Premier Healthcare database. • S. ST (43.39% vs. 35) • S. ST (43.39% vs. 35) • S. ST (0001); • Paroxysmal AF: • Output •	2019a States	e study Patients with a primar diagnosis of AF (≥18 years) who underwent radiofrequency ablatio between 09/01/2016– 03/31/2018, identified from the Premier	(n=1,766) (35.09% vs. 30.18%, $p=0.0031$); n Clinical characteristics • Paroxysmal AF: STSF vs. ST (63.32% vs. 67.21%, $p=0.0210$); • CHADS ₂ VASc scort 3: STSF vs. ST (43.39% vs. 358%, p<0.001);	ST (3.5% vs. 3.7%). Not reported

					Exclusion criteria: Unspecified.		Comorbidities • Obesity: STSF res. SG (23.88% vs. 19.42%, p=0 #022%	
							Comorbidities • Obesity: STSF 5. St (23.88%	
							• Diabetes: STSI v. gr (20.90% vs. 17.27%, p=0.0000 • Atrial flutter: St SF vs. ST (41.38% vs. 32.67%, p<0.0001); • Valvular disease: SF vs. ST (21.87% vs. 12.34%, q<0.0001); • Cardiomyopath F vs. ST (12.87% vs. 9.68%) PS vs. ST (12.87% vs. 9.68%) PS vs. ST (69.48% vs. 63.06%; p=0.0001); • Heart failure: St f ss. ST	
	United Ab States	bstract	English	Retrospectiv e study	Inclusion criteria: Patients with a primary diagnosis of AF (≥18 years) who underwent index (first occurrence) radiofrequency ablation in an outpatient setting (09/01/2016– 03/31/2018), identified from the Premier Healthcare database. Exclusion criteria: Unspecified.	STSF (n=571) vs. ST (n=571)	(20.69% vs. 17.8 m baded from http://bmjopen.bmj.com Al training, Al training, and si	Hospital readmission outcom • 4-6 months all-cause readmission rate: STSF vs. S (2.78% vs. 2.78%, <i>p</i> =1.000); • 4-6 months cardiovascular- related inpatient readmission rate: STSF vs. ST (1.23% vs. 1.23%, <i>p</i> =1.000); • 4-6 months AF-related inpatient readmission rate: STSF vs. ST (0.93% vs. 0.62%, <i>p</i> =0.6535).
[15]	Korea	bstract	English	Prospective cohort study	Inclusion criteria: Drug refractory symptomatic AF patients. Exclusion criteria: Unspecified.	STSF (n=66) vs. ST (n=32)	Pooled information of wo groups Demographics and L • Mean age: 61±&years Clinical characterstics • Paroxysmal Algorov at Agence	 Procedural characteristics Procedure time: STSF vs. S (160±37 vs. 199±42 minutes, p<0.001); Ablation time: STSF vs. ST (44±10 vs. 66±14 minutes, p<0.001); Clinical outcomes Acute procedure success rat STSF vs. ST (96.3% vs. 95.8%, p=0.613).
	South Ab Korea	bstract	English	Retrospectiv e study	Inclusion criteria: Drug refractory symptomatic AF patients.	STSF (n=39) vs. ST (n=32)	Pooled information o Stwo groups Demographics Si Mean age: 61±10 years;	Procedural characteristics

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	Liu 2019 [26]	China	Full text	Chinese	Retrospectiv e study	Exclusion criteria: Unspecified. Inclusion criteria: Drug- refractory paroxysmal AF patients underwent	STSF (n=24) vs. ST (n=24)	Stress Stress Male: 79%; Clinical character Male: 79%; Clinical character Clinical character Stress Paroxysmal AF: Stress Paroxysmal AF: Stress Demographics Stress • Mean age: STS Stress	 Procedure time: STSF vs. ST (168±34 vs. 199±42 minutes, p=0.001); Ablation time: STSF vs. ST (47±11 vs. 66±14 minutes, p<0.001); Clinical outcomes Acute procedure success rate: STSF vs. ST (96.0% vs. 95.8%, p=0.867); Any complications: STSF vs. ST (0% vs. 0%). Procedural characteristics Procedure time: STSF vs. ST (67 vs. 70 minutes, p=0.45); Ablation firme STSF
						pulmonary vein isolation. Exclusion criteria: Unspecified.	ЭЦ О	p=0.95); • Male: STSF vs (7.5%) vs. (7.5%), $p=1.00$; • BMI: STSF vs. (7.5%), $p=1.00$; • BMI: STSF vs. (7.5%), $p=1.00$; • BMI: STSF vs. (7.5%), $p=1.00$; • Clinical characteristics • Duration of AFaSTSF vs. ST $(10.4\pm10.1 \text{ vs. } 6\pm4.3 \text{ months}, p=0.08$; • Left atrial diameter; (7.5%), $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$, $(7.5%)$	 Ablation time: STSF vs. ST (35.3±6.4 vs. 39.6±9.0 minutes, p=0.07); Fluoroscopy time: STSF vs. ST (7.8±3.1 vs. 11.2±6.3 minutes, p=0.02); Total infusion fluid: STSF vs. ST (356 vs. 700 mL, p<0.01); Clinical outcomes Acute procedure success rate: STSF vs. ST (100% vs. 100%, p=1); Any complications: STSF vs. ST (0% vs. 0%).
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Solimene Italy 2019 [12]	Full text	English Prospective cohort study	Inclusion criteria: Patients with paroxysmal or persistent AF who underwent their first AF ablation. Exclusion criteria: 1. Age <18; 2. Longstanding persistent AF (AF was the sole rhythm for the last 12 months); 3. AF secondary to a transient or correctable abnormality, including electrolyte imbalance, trauma, recent surgery, infection, toxic ingestion, and endocrinopathy; 4. Intra-atrial thrombus, tumor, or other abnormality precluding catheter insertion; 5. Left ventricular ejection fraction <35%; 6. Women of childbearing potential who are or might be pregnant; 7. Hematological contraindications to ionizing radiation exposure; 8. Presence of complex congenital heart disease; 9. Cardiac surgery within 1 month from enrollment.	STSF (Subgroup with AI 330-450, n=162; Subgroup with AI 380-500, n=151) vs. ST (Subgroup with AI 330-450, n=96; Subgroup with AI 380- 500, n=81)	The subgroup with AP 30-450 Demographics C • Mean age: STS F vs. S T (60±12 vs. 58±10 years) b • Male: STSF vs. S T (68% vs. 71%); • BMI: STSF vs. S T (67.5±4.3 vs. 27.2±3.8 kg/m ²); S F S S • Paroxysmal AF S S F vs. ST (79.6% vs. 81.3%); B S S S S S S S S S S	The subgroup with AI 330-45 Procedural characteristics • Procedure time: STSF vs. S (120±72 vs. 129±44 minutes) • Ablation time: STSF vs. ST (33.3±11.5 vs. 30.7±10 minutes); • Fluoroscopy time: STSF vs ST (257±356 vs. 542±285 seconds); • Total fluid: STSF vs. ST (701±287 vs. 1105±573 mL); Clinical outcomes • Acute procedure success rat STSF vs. ST (94.5% vs. 97.5%); The subgroup with AI 380-50 Procedural characteristics • Procedure time: STSF vs. S (125±73 vs. 144±44 minutes); • Ablation time: STSF vs. ST (33±11.7 vs. 28.8±13.7 minutes); • Fluoroscopy time: STSF vs. ST (379±454 vs. 540±416 seconds); • Total fluid: STSF vs. ST (836±503 vs. 1,732±664 mL) Clinical outcomes • Acute procedure success rat STSF vs. ST (92.2% vs. 94.5%).

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1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42	Plenge Germany 2020 [11]	English	Prospective cohort study		STSF (n=60) vs. ST (n=20)	• Left ventricular ejection fraction: STSF v. ST60±7 vs. $57\pm7\%$); • Comorbidities • Hypertension: STSF vs. ST (45.7% vs. 39.5%); • Ischemic heart visitade: STSF vs. ST (5.5% vs. 4.9%); • Valvulopathy: STSF vs. ST (2.6% vs. 6.2%); • Dilated cardion vertication vertication attack/Stroke: STSF vs. ST (2.6% vs. 6.2%); • Previous transit vs. ST (2.6% vs. 1.2%); • Diabetes mellitus SS SF vs. ST (4% vs. 6.2%); • Diabetes mellitus SS SF vs. ST (63.0±9.1 vs. 657±1067 vs. ST (79.6±97.2 vs. 858±100.7 months, p=0.82) • Left atrial diameter: STSF vs. ST (41.2±7.0 vs. 62.7±6.3 mm, p=0.64); • Left ventricular ejection fraction: STSF vs. ST (65% vs. 73.3%, p=0.99); • Left ventricular ejection fraction: STSF vs. ST (65% vs. 73.3%, p=0.99); • Hyperlipoproteinenge: STSF vs. ST (33.3% vs. 40%, p0.42);	Procedural characteristics • Procedure time: STSF vs. ST (106.3 \pm 28.4 vs. 116.7 \pm 26.7 minutes, p =0.2); • Ablation time: STSF vs. ST (25.9 \pm 7.3 vs. 32.1 \pm 16 minutes, p=0.045); • RF time for PVI left veins: STSF vs. ST (836.5 \pm 296.3 vs. 1,086.6 \pm 523.0 seconds, p=0.08); • RF time for PVI right veins: STSF vs. ST (913.5 \pm 1,435.8 vs. 1,002.8 \pm 544.6 seconds, p=0.8); • Fluoroscopy time: STSF vs. ST (16.0 \pm 6.7 vs. 13.8 \pm 5.7 minutes, p =0.25) • Fluoroscopy dose: STSF vs. ST (1,854.7 \pm 1,247.9 vs. 1,756.7 \pm 822.6 μ Gym2, p=0.77); • Fluid via ablation catheter: STSF vs. ST (241.4 \pm 79.6 vs. 540.3 \pm 229.5 mL, p <0.01);
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0 1 2								• Cardiovascular disease: STSF vs. ST (20% vs. \mathbf{y})%, \mathbf{y} =0.10); • Cardiomyopatha: ST&F vs. ST (15% vs. 13.3%, \mathbf{y} =0.22); • Diabetes mellites: ST&F vs. ST (15% vs. 13.3%, \mathbf{y} =0.22); • Renal failure: ST&F vs. ST (11.7% vs. 0%, \mathbf{y} =0.22); • Sleep-disordered from thing: STSF vs. ST (8.849) S6.7%, p=0.63).	Clinical outcomes • Any complications: STSF vs. ST (1.7% vs. 5%); • Audible steam pop: STSF vs. ST (1.7% vs. 0%); • Bleeding: STSF vs. ST (0% vs. 5%).
3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 0 1 2 3 4 5 6 6 7 8 9 0 0 1 2 3 4 5 5 6 7 8 9 0 0 1 1 2 3 4 5 5 6 7 8 9 0 0 1 1 2 3 4 4 5 5 6 7 8 9 0 0 1 1 2 3 4 4 5 5 6 7 8 9 0 0 1 1 2 3 4 4 5 5 6 7 8 9 0 0 1 1 2 3 4 4 5 5 6 7 8 9 0 0 1 1 2 3 4 4 5 5 6 7 8 9 0 0 1 1 2 3 4 4 5 5 6 7 8 9 0 0 1 1 2 3 4 4 5 5 6 7 8 9 0 0 1 1 2 3 4 4 5 5 6 6 7 7 8 9 0 0 1 1 2 3 3 4 4 5 5 6 6 7 7 8 9 9 0 0 1 1 2 3 3 4 4 5 5 6 6 7 7 8 9 9 0 0 1 1 2 3 3 4 4 5 5 6 6 7 7 8 9 9 0 0 1 1 2 3 3 4 4 5 5 6 6 7 7 8 9 9 0 0 1 1 2 3 3 4 4 5 5 6 6 7 7 8 9 9 0 0 1 1 2 3 3 4 4 5 5 6 7 7 8 9 9 0 0 1 1 2 3 3 4 5 5 7 8 9 9 0 0 1 1 2 3 3 4 5 5 7 8 9 9 0 0 1 1 2 3 3 4 5 5 8 9 9 0 0 1 1 2 3 3 4 5 5 7 8 9 9 0 0 1 1 2 3 3 4 5 5 7 8 9 9 0 0 1 1 2 3 3 1 1 1 5 5 8 9 9 0 0 1 1 2 3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	Stabile 2020 [22]	Italy	Full text	English	Prospective cohort study	Inclusion criteria: Patients with paroxysmal or persistent AF who underwent their first AF ablation. Exclusion criteria: 1. Age <18; 2. Longstanding persistent AF (AF was the sole rhythm for the last 12 months); 3. AF secondary to a transient or correctable abnormality, including electrolyte imbalance, trauma, recent surgery, infection, toxic ingestion, and endocrinopathy; 4. Intra-atrial thrombus, tumor, or other abnormality precluding catheter insertion; 5. Left ventricular ejection fraction <35%; 6. Women of childbearing potential who are or might be pregnant; 7. Hematological contraindications to	STSF (Subgroup with AI 330-450, n=140; Subgroup with AI 380-500, n=149) vs. ST (Subgroup with AI 330-450, n=89; Subgroup with AI 380- 500, n=74)	Duplicate with Superieur (ABES) . Biometry (ABES) . All training, Al training, and similar technologies.	The subgroup with AI 330-450 Clinical outcomes • 12-month arrhythmia recurrence rate: STSF vs. ST (14.9% vs. 4.5%); The subgroup with AI 380-500 Clinical outcomes • 12-month arrhythmia recurrence rate: STSF vs. ST (9.4% vs. 12.2%).
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$ \begin{array}{r} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ 12 \\ 13 \\ 14 \\ 15 \\ 16 \\ 17 \\ 18 \\ 19 \\ 20 \\ 21 \\ 22 \\ 23 \\ 24 \\ 25 \\ 26 \\ 27 \\ 28 \\ 29 \\ 30 \\ 31 \\ 32 \\ 33 \\ 34 \\ 35 \\ 36 \\ 37 \\ 38 \\ 39 \\ 40 \\ \end{array} $	Zhang 2020 [27]	China	Full text	Chinese	Retrospectiv e study	ionizing radiation exposure; 8. Presence of complex congenital heart disease; 9. Cardiac surgery within 1 month from enrollment. Inclusion criteria: 1. Recurrent paroxysmal atrial fibrillation (defined as paroxysmal atrial fibrillation that can be terminated by itself or intervention within 7 days after the attack), which does not respond to antiarrhythmic drugs. 2. Preoperative echocardiography showed left atrial diameter <55mm and left ventricular ejection fraction (LVEF) > 35%. Exclusion criteria: Stroke, heart valve disease, heart failure (cardiac function IV level), atrial thrombus, cardiomyopathy (including hypertrophic cardiomyopathy), acute coronary syndrome, hypethyroidism, hypothyroidism, coronary heart disease, chronic renal insufficiency (chronic kidney disease stage 4-	STSF (n=34) vs. ST (n=34)	Cted by copyright, including for uses reseived by copyrise includin	Procedural characteristics • Right PVI time: STSF vs. ST (23.30 \pm 5.53 vs. 28.65 \pm 4.95 minutes, p <0.05); • Left PVI time: STSF vs. ST (28.25 \pm 9.67 vs. 33.25 \pm 5.60 minutes, p <0.05); • Fluoroscopy time: STSF vs. ST (11.30 \pm 2.91 vs. 12.30 \pm 3.31 minutes, p >0.05); • Total fluid: STSF vs. ST (930.00 \pm 319.70 vs. 1,770.00 \pm 482.43 mL); Clinical outcomes • Unilateral PVI success rate: STSF vs. ST (88.23% vs. 58.82%, p <0.05); • Cardiac tamponade: STSF vs. ST (2.9% vs. 2.9%); • Eschar: STSF vs. ST (0.0% vs. 8.8%, p <0.05).
41 42 43 44 45 46 47				For peer	review only - ht	5) tp://bmjopen.bmj.com/	ˈsite/about/guidel	Bibliog raphique de	

					BMJ Open		Cted by copyright Demographics • Mean age: STSE vs.5 (62 3+8 8 vg. 61 #±10 vg.arg	Page 4
Huang 2021 [17]	China	Full text	Chinese	Retrospectiv e study	Inclusion criteria: 1. Aged between 18 and 75 years; 2. ECG examination confirmed AF attack. Exclusion criteria: 1. Patients with cardiac thrombosis; 2. Patients complicated with active hemorrhagic disease, or advanced chronic wasting disease; 3. Left atrial diameter > 55mm; 4. Patients with valvular heart disease or vascular disease requiring surgical treatment.	STSF (n=42) vs. ST (n=42)	Demographics	Procedural characteristics • Ablation time: STSF vs. ST (28.3 \pm 5.1 vs. 51.3 \pm 6.7 minutes, p <0.001); Clinical outcomes • Circumferential pulmonary vein isolation success rate: STSF vs. ST (100.0% vs. 100.0%, p =1.000); • Complement ablation rate in CPVI: STSF vs. ST (45.2% v 85.7%, p =0.087); • 12-month arrhythmia recurrence rate: STSF vs. ST (0% vs. 2.4%, p =0.314); • Any complications: STSF v ST (0% vs. 0%).
Zhou 2021 [13]	China	Full text	Chinese	Retrospectiv e study	Inclusion criteria: Patients undergoing first-time percutaneous radiofrequency catheter ablation. Exclusion criteria: Unspecified.	STSF (n=142) vs. ST (n=98)	Demographics a • Mean age: STS f vs. ST ($63,2\pm9,2$ vs. 633 ± 1006 years, p=0.950); b • Male: STSF vs. ST ($53\%, p=0.491$); c Clinical characteristics • Paroxysmal AF: STEF vs. ST (59.9% vs. $66.3\%, p=3335$); • Left atrial diameter: C TSF vs. ST (43.4 ± 4.4 vs. 44.4 E S mm, p=0.193); b i i i i i i i i	Procedural characteristics • Procedure time: STSF vs. S (96.4 \pm 31.6 vs. 119.5 \pm 33.8 minutes, p=0.021); • Ablation time: STSF vs. ST (38.6 \pm 15.2 vs. 61.5 \pm 13.8 minutes, p=0.013); • Fluoroscopy time: STSF vs ST (15.3 \pm 3.3 vs. 16.9 \pm 3.6 minutes, p=0.144); Clinical outcomes • 12-month arrhythmia recurrence rate: STSF vs. ST (4.9% vs. 20.4%, p=0.025).

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							 Left ventricular ejection fraction: STSF vz ST361.4±5.7 vs. 61.2±5.1%, p=0.840); CHA₂DS₂ VAS Score: STSF vs. ST (2.3±1.7 G. 1.9±1.7, n=0.243) 	
Dugo 2016 [29		Abstract	English	Retrospectiv e study	Inclusion criteria: Patients with AF underwent ablation between July 2014 and May 2015, with a minimum follow-up of 6 months. Exclusion criteria: Unspecified.	STSF (n=26) vs. SF (n=26)	 percent of the second second	 Procedural characteristics Procedure time: STSF vs. S (98±32 vs. 78±31 minutes, p 0.05); Fluoroscopy time: STSF vs SF (11±7 vs. 7±3 minutes, p 0.05); Clinical outcomes Acute procedure success ra STSF vs. SF (100% vs. 100% Any complications: STSF vs SF (0% vs. 0%); Cardiac tamponade: STSF SF (0% vs. 0%); Stroke: STSF vs. SF (0% vs. 0%); Atrial-esophageal fistula: STSF vs. SF (0% vs. 0%); Vascular access: STSF vs. (3.8% vs. 0%);
Gonna 2017 [30	United Kingdom	Full text	English	Prospective cohort study	Inclusion criteria: Atrial fibrillation patients undergoing ablation, Between May and December 2015. Exclusion criteria: Unspecified.	STSF (n=100) vs. SF (n=100)	Demographics d • Mean age: STS E .vs 3 F (60.5 ± 14.0 vs. 614 ± 16.3 years, p=0.38); • Male: STSF vs 6 SF (13% vs. 71%, $p=0.75$). h 1 1 2025 at Agence B	 Procedural characteristics Mean procedure time: STS vs. SF (225.5 vs. 221.4 minutes, p=0.55); Mean fluoroscopy time: STSF vs. SF (25.8 vs. 30.0 minutes, p=0.03); Clinical outcomes Any complications: STSF SF (0% vs. 2%, p=0.16); Pericardial effusion: STSF vs. SF (0% vs. 1%, p=0.32); Atrioventricular block: ST vs. SF (0% vs. 1%, p=0.32).
Takamiya 2020 [32]		Full text	English	Retrospectiv e study	Inclusion criteria: Patients who underwent	STSF (n=74) vs. SF (n=74)	Demographics Dig ines.xhtml de	Procedural characteristics

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1 2							6/bmjopen-2023- cted by copyrigh	
3 4 5						first catheter ablation for drug-refractory persistent AF.	 Mean age: STSF vs. SF (63±10 vs. 63±12 years, =0.52); Male: STSF vs. SF (26% vs. 80%, p=0.69); 	 Procedure time: STSF vs. SF (180 vs. 200 minutes, p=0.150); Fluoroscopy time: STSF vs.
6 7 8						Exclusion criteria: Unspecified.	• BMI: STSF vs: $93F(25\pm4 \text{ vs.} 25\pm4 \text{ kg/m}^2, p=00)$	SF (67 vs. 76 minutes, $p=0.026$);
9 10 11 12							Clinical characters and the state of the sta	Clinical outcomes • 12-month arrhythmia recurrence rate: STSF vs. SF (15% vs. 30%);
13 14 15							months, $p=0.30$) for the second sec	 Any complications: STSF vs. SF (5% vs. 3%, p=1.0); Pericardial effusion: STSF vs. SF (1.4% vs. 1.4%);
16 17 18 19							58±14%, p=0.57 data Comorbidities • Heart failure: Sale as SF (18% vs. 20%, p=0.83	 Esophageal gastroparesis: STSF vs. SF (1.4% vs. 0%); Phrenic nerve injury: STSF vs. SF (1.4% vs. 0%);
20 21 22							vs. 20%, $p=0.83$ • Hypertension: SF (61% vs. 54%, $p=0.5$ • Diabetes mellitus: SF vs. SF	 Aspiration pneumonia: STSF vs. SF (1.4% vs. 0%); Sinus node injury as a result of superior vena cava isolation:
23 24 25 26 27	Uetake 2020 [31]	Japan	Full text	English	Prospective cohort study	Inclusion criteria: STSF (n=298 Paroxysmal AF patients vs. SF (n=97) who underwent their first radiofrequency	• Mean age: STS vs. SF (65.3 ± 9.9 vs. $63a\pm9.2$ years, p=0.085);	STSF vs. SF (0% vs. 1.4%).Procedural characteristics• Ablation time: STSF vs. SF(2,056.8±534.5 vs.2,401.1±733.4 seconds,
27 28 29 30						catheter ablation procedure. Exclusion criteria:	• Male: STSF vs 2 SF 5 8.8% vs. 79.4%, <i>p</i> =0.028 2 . • BMI: STSF vs. 3 SF (2 4.1±3.5 vs. 24.0±3.1 kg/m ² , 3 =0. 43 5);	<i>p</i><0.001);Clinical outcomesAcute procedure success rate:
31 32 33						 Severe valvular disease; Left ventricular ejection fraction < 35%; 	Clinical characteristics • Duration of AFOSTSF vs. SF	STSF vs. SF (100% vs. 100%); • 12-month arrhythmia recurrence rate: STSF vs. SF (21.8% vs. 43.3%, p <0.001).
34 35 36 27						 3. Left atrial dimension > 55 mm; 4. Active thyroid disease; 	(32.1±33.5 vs. 29±432 months, p=0.023); • Left atrial diameter: TSF vs. SF (41.0±6.0 vs. 40.65.9 mm, p=0.709);	(21.070 43. 19.970, p *0.001).
37 38 39 40						5. Hypertrophic cardiomyopathy; 6. Hemodialysis;	• Left ventricular ejection fraction: STSF vs. SF Q 65.8±7.7 vs. 65.5±8.4%, <i>p</i> =0.8 Q ;	
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						7 Lles of antiorrhythmia			
D 1 2 3 4 5						7. Use of antiarrhythmic drugs during the blanking period.		• CHA ₂ DS ₂ VASC Scale: STSF vs. SF (1.94 \pm 1.2g vs. 551 \pm 1.13, p=0.010); • Hypertension: 9 SF7 s. SF (53.4% vs. 52.6% p=0.493); • Congestive heat Figure: STSF vs. SF (4.7% vs. 7. 9 p=0.203); • Diabetes mellites SE8F vs. SF (10.1% vs. 13.4% p=2230); • Previous stroke operansient ischemic attack: 3 TS 6 vs. SF (3.4% vs. 1.0%, 2 6 2 2 2); • Vascular diseas: 5 5 F vs. SF	
6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1	Ikeda 2021 [33]	Japan	Full text	English	Retrospectiv e study	Inclusion criteria: 1. Age of > 20 years and provision of informed consent to undergo a second AF ablation at our institute, the performance of the second AF ablation using high-density mapping or the conventional method (CARTO [®] mapping system; Biosense Webster, Irvine, CA, USA) during that period; 2. \geq 3 months of follow- up at the outpatient clinic in our institute. Exclusion criteria: 1. Refusal to participate in the study; 2. An inability to undergo follow-up for any reason; 3. The lack of use of a 3D mapping system.	STSF (n=51) vs. CELSIUS® (n=49)	(5.7% vs. 1.0%, $p = 0$ (5.7% vs. 1.0%, $p = 0$ (5.5). Demographics $q = 0$ (6.5). Demographics $q = 0$ (7.5). Demographics $q = 0$ (7.5). Demographics $q = 0$ (7.5). Demographic	Procedural characteristics • Procedure time: STSF vs. CELSIUS® (260.5±82.7 vs. 255.8±45.3 minutes, p =0.82); • Fluoroscopy dose: STSF vs. CELSIUS® (313.2±187.9 vs. 363.4±257.3 mGy, p =0.28); Clinical outcomes • 12-month arrhythmia recurrence rate: STSF vs. CELSIUS® (33% vs. 16%, p=0.017); • Cardiac tamponade: STSF vs. CELSIUS® (0% vs. 0%); • Cerebral infarction: STSF vs. CELSIUS® (0% vs. 0%); • Bleeding: STSF vs. CELSIUS® (13.7% vs. 10.2%) • Congestive heart failure: STSF vs. CELSIUS® (2% vs. 0%, p =0.32); • Pericarditis: STSF vs. CELSIUS® (2% vs. 0%, p=0.32).
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D.:							• Diabetes mellitus: SSF vs. CELSIUS [®] (2% \overrightarrow{Rs} : 8 \overleftarrow{k} , p=0.15); • Chronic kidney disede: STSF vs. CELSIUS [®] (\overrightarrow{Rs} vg 16%, p=0.19).	D
Reinsch 2021 [36]	Germany	Full text	English	Retrospectiv e study	Inclusion criteria: Atrial fibrillation patients undergoing ablation at the Alfried Krupp Krankenhaus, Essen, Germany from October 2014 to June 2019. Exclusion criteria: Unspecified.	STSF (n=690) vs. Thermocool NAVISTAR® (n=99)	Demographics o • Mean age: STSF, vs. Thermocool NASINIPR® (67.5 ± 10.6 vs. 62.6000 years); • Male: STSF vs. Thermocool NASISTOR ® (43.5% vs. 48.5% b • Paroxysmal AFS • Paroxysmal AFS • Duration of AFass • Left ventricular • Control NASISTAR® (50.1 ± 57.5 vs. 535000.4 months); • Left ventricular • Control NASISTAR® (77.5% vs. 81.8% ; • CHA ₂ DS ₂ VASS Sere ≥ 3 : STSF vs. Thermocool & AVISTAR® (57.0% vs. 46.9% ; • Hypertension: D ISFors. Thermocool NASISTAR® (57.0% vs. 46.9% ; • Hypertension: D ISFors. Thermocool NASISTAR® (69.9% vs. 57.6%).	Procedural characteristics • Procedure time: STSF v Thermocool NAVISTAR (160±48 vs. 190±47 minu • Ablation time: STSF vs Thermocool NAVISTAR (43±19 vs. 58±27 minute • Fluoroscopy time: STSI Thermocool NAVISTAR (5±3 vs. 7±4 minutes); Clinical outcomes • Cardiac tamponade: ST Thermocool NAVISTAR (1.7% vs. 2.9%).
Di 2020 [35]	Italy	Abstract	English	Prospective cohort study	Inclusion criteria: Patients with paroxysmal or persistent AF underwent point-by- point pulmonary vein isolation. Exclusion criteria: Unspecified.	CARTO+STSF (n=59) vs. Rhythmia System™ + DirectSense (n=57)	Pooled information of two groups Clinical characteristics • Paroxysmal Algo s. at Agence Bibliographique lines.xhtml	Procedural characteristic • Procedure time: CARTO+STSF vs. Rhytl System TM + DirectSense (180±56 vs. 180±89 min p=0.590); • Fluoroscopy time: CARTO+STSF vs. Rhytl System TM + DirectSense vs. 20±12 minutes, p=0.0 Clinical outcomes

Page 49 of 55	BMJ Open	6/bmjopen-2 cted by copy	
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37		25 at Agen es.	• Acute procedure success rate: CARTO+STSF vs. Rhythmia System TM + DirectSense (100% vs. 100%); • 9-month arrhythmia recurrence rate: CARTO+STSF vs. Rhythmia System TM + DirectSense(14% vs. 25%, $p=0.2$); • Any complications: CARTO+STSF vs. Rhythmia System TM + DirectSense (0% vs. 0%); • Audible steam pop: CARTO+STSF vs. Rhythmia System TM + DirectSense (0% vs. 0%). Procedural characteristics • Procedure time: STSF vs. DiamondTemp TM (78.2±25.6 vs. 98.8±30.1 minutes, p=0.002); • Ablation time: STSF vs. DiamondTemp TM (1,035.5±287.2 vs.792.1±311.2 seconds, $p<0.001$); • Fluoroscopy time: STSF vs. DiamondTemp TM (5.5±2.5 vs.4.6±2.1 minutes, $p<0.006$); • Fluoroscopy dose: STSF vs. DiamondTemp TM (295.8±247.5 vs. 183.8±178.1 yGym2, $p<0.013$); Clinical outcomes • Acute procedure success rate: STSF vs. DiamondTemp TM (100% vs. 100%); • Acute stroke: STSF vs. DiamondTemp TM
38 39 40 41 42 43 44	STSF: SMARTTOUCH® SURROUNDFLOW; ST: ST: THERMOCOOL SMARTTOUCH®; SF: SURROUNDFLOW; BMI: Body mass i	Bibliographique	
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PRISMA 2020 Checklist

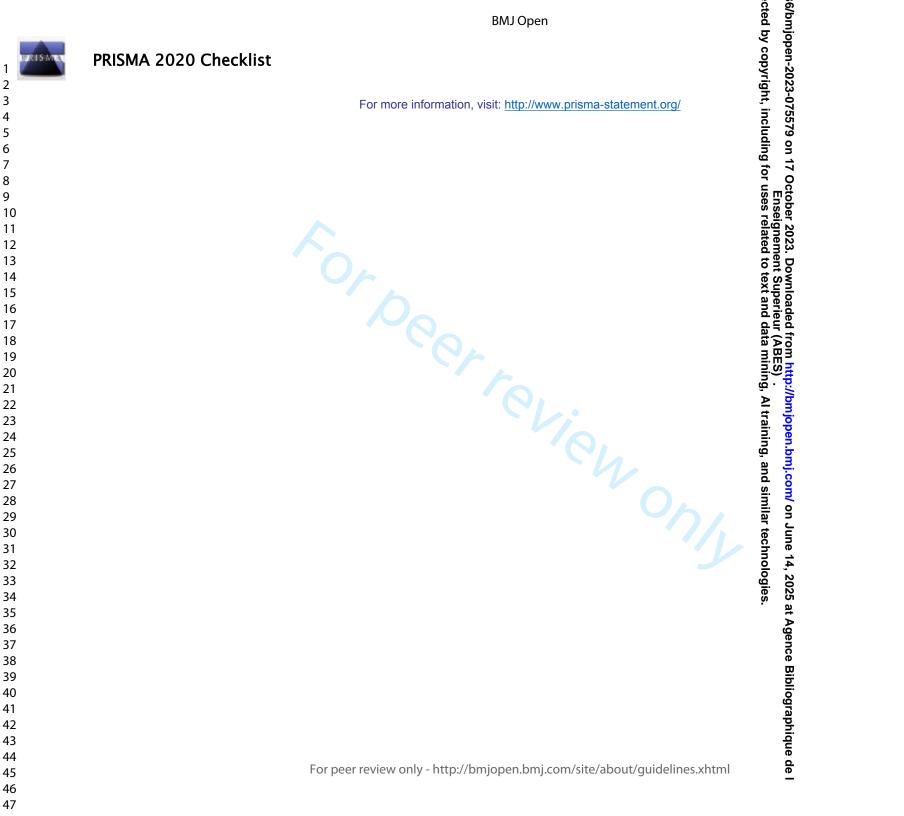
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1	PRISM	ИА 20	BMJ Open de by copyrigh D20 Checklist	
3 4 5	Section and Topic	ltem #	Checklist item	Location where item is reported
6	TITLE	I		
7	Title	1	Identify the report as a systematic review.	Line 1 to 4
8 9	ABSTRACT	1	See the PRISMA 2020 for Abstracts checklist.	
10	Abstract	2	See the PRISMA 2020 for Abstracts checklist.	See abstract
11	INTRODUCTION	-	Describe the rationale for the review in the context of existing knowledge.	
12	Rationale	3	Describe the rationale for the review in the context of existing knowledge.	Line 58 to 61
13	Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	Line 61 to 65
14 15	METHODS		Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	
16	Eligibility criteria	5		Line 73 to 80
17 18	Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulting identify studies. Specify the date when each source was last searched or consulted.	Line 84 to 92
19 20	Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used	Supplementary Table 2
20 21 22	Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation bools as in the process.	Line 94 to 99, and Figure 1
23 24 25	Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each epert, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	Line 101 to 107, and Figure 1
26 27	Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with gack outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which esues to collect.	Line 112 to 116
28 29		10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, Jinding sources). Describe any assumptions made about any missing or unclear information.	Line 109 to 111
30 31	Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	Line 119 to 124
32 33	Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	Line 126 to 132
34 35	Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the stud vention characteristics and comparing against the planned groups for each synthesis (item #5)).	Line 134 to 138
36 37		13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing sum are statistics, or data conversions.	Not applicable
38 39		13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	Supplementary Table 1
40 41 42		13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used	Line 138 to 141, and Line 147 to 149
43 44		13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analy is, meta-regression).	Line 142 to
44 45			For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml	145
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PRISMA 2020 Checklist

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Section and Topic	ltem #	Checklist item	Location where item is reported
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	Line 145 to 146
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting bias of).	Line 146 to 147
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	Line 138 to 141
RESULTS		<u> </u>	
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the search and selection process, from the number of records identified in the search to the search to the search to the search in the review, ideally using a flow diagram.	Line 152 to 157, and Figure 1
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they we excluded.	
Study characteristics	17	Cite each included study and present its characteristics.	Line 159 to 162, and Supplementary Table 1
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	Line 171 to 173, and Supplementary Table 1
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	Line 283 to 285, Line 288 to 290, Line 293 to 294, and Line 302 to 314
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	Line 175 to 180
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summarized synate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direct of the effect.	Line 183 to 185, Line 206 to 207, Line 229 to 231, Line 248 to 251, Line 267 to 270, Line 279 to 281, Line 291 to 292, and Line 295 to 297
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	Line 186 to 196, Line 208
		For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml	to 221, Line

ge 55 of 55		BMJ Open de By og	
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Section and Topic	ltem #	Checklist item	Location where item reported
		on 17 Octol En Ing for use	232 to 240, Line 251 to 259, and Lin 271 to 274
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	Line 197 to 199, Line 22 to 223, Line 241 to 242, Line 259 to 261, and Lin 274 to 277
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis a set of the synthesis a se	Line 199 to 202, and Lin 223 to 224
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	Figure 2, 3, and 5, and Table 1
DISCUSSION	<u>. </u>		
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	Line 316 to 324
	23b	Discuss any limitations of the evidence included in the review.	Line 379 to 399
	23c	Discuss any limitations of the review processes used.	Line 389 to 391
	23d	Discuss implications of the results for practice, policy, and future research.	Line 358 to 360, and Lin 397 to 399
OTHER INFORMA	TION		
Registration and	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	Not applicab
protocol	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	Not applicat
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	Not applicat
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the private view.	Line 436
Competing interests	26	Declare any competing interests of review authors.	Line 432 to 434
	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	Upon reque



BMJ Open

Comparisons of Procedural Characteristics and Clinical Outcomes between SMARTTOUCH® SURROUNDFLOW Catheter and Other Catheters for Atrial Fibrillation Radiofrequency Catheter Ablation: A Systematic Literature Review

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Primary Subject Heading :	Cardiovascular medicine
Secondary Subject Heading:	Cardiovascular medicine
Keywords:	CARDIOLOGY, Systematic Review, Cardiac surgery < SURGERY

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Comparisons of Procedural Characteristics and Clinical Outcomes between SMARTTOUCH[®] SURROUNDFLOW Catheter and Other Catheters for Atrial Fibrillation Radiofrequency Catheter Ablation: A Systematic Literature Review

Jianyong Li^{1,†}, Guifang Zhou^{1,†}, Xinzhong Li^{1,#}, Senlin Huang^{1,#}, Hairuo Lin^{1,#}, Shaopeng Lin^{1,#}, Liang Tan²,
Wendong Chen^{3,4}, Xiaobo Huang^{1,*}, Yuegang Wang^{1,*}

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- 18 11 [†]These authors contributed equally to this work and share the first authorship.
- 19 12 #These authors contributed equally to this work and share senior authorship.
- 20 13 *These authors contributed equally to this work and share the last authorship.

22 14 Abstract

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23 15 Background: SMARTTOUCH® SURROUNDFLOW (STSF) catheter is the new generation of SMARTTOUCH 24 (ST) catheter with an upgraded irrigation system for radiofrequency catheter ablation (RFCA) in patients with atrial 16 25 26 17 fibrillation (AF). Methods: This systematic literature review searched the major English and Chinese bibliographic 27 18 databases from 2016 to 2022 for any original clinical studies assessing the STSF catheter for RFCA in AF patients. 28 19 Meta-analysis with random effects model was used for evidence synthesis. Results: Pooled outcomes from 19 29 30 20 included studies indicated that STSF catheter was associated with a significantly shorter procedure time [weighted 31 21 mean difference (WMD): -17.4 minutes, p < 0.001], shorter ablation time (WMD: -6.6 minutes, p < 0.001), and lower 32 22 catheter irrigation fluid volume (WMD: -492.7 ml, p<0.001) than ST catheter. Pooled outcomes from 4 included 33 34 23 studies with paroxysmal AF patients reported that using the STSF catheter for RFCA was associated with a 35 24 significantly shorter ablation time (WMD: -5.7 minutes, p < 0.001) and a lower risk of one-year post-ablation 36 25 arrhythmia recurrence (rate ratio: 0.504, p<0.001) than the SURROUNDFLOW (SF) catheter. Significant 37 38 26 reductions in procedure time and ablation time associated with the STSF catheter were also reported in the other 4 39 27 studies using non-ST/SF catheters as the control. Overall complications of STSF catheter and control catheters were 40 28 comparable. Conclusions: Using the STSF catheter was superior to using the ST catheter to conduct RFCA for AF 41 29 by significantly reducing procedure time, ablation time, fluoroscopy time, and irrigation fluid volume. The 42 43 30 superiority of the STSF catheter over the SF catheter and other non-ST/SF catheters for RFCA needs further 44 31 confirmation. 45

32 Strengths and limitations of this study

- Improve the generalizability of the pooled evidence by updating the published evidence and including studies published in Chinese journals.
- Conduct heterogeneity analyses, sensitivity analysis, and publication bias analysis to confirm the robustness of the pooled evidence.
- Most of the included studies in this review were observational studies that could introduce heterogeneity in the pooled evidence.
- The pooled evidence is robust for the comparisons between SMARTTOUCH[®] SURROUNDFLOW catheter and SMARTTOUCH[®] catheter but not for the comparisons between the other catheter types due to paucity of existing evidence.

Keywords

atrial fibrillation; radiofrequency catheter ablation; SMARTTOUCH® SURROUNDFLOW; systematic literature review; meta-analysis

1. Introduction

Radiofrequency catheter ablation (RFCA) plays a critical role in managing atrial fibrillation (AF), which affects 1.6% of the Chinese adult population and is rising in prevalence along with the aging population in China [1]. RFCA was originally conducted using a non-contact force (CF)-sensing catheter, whose use is now discouraged due to the inadequate lesion formation caused by insufficient CF or complications (such as cardiac perforation and atrioesophageal fistula) caused by excessive CF [2]. Thus, a CF-sensing catheter was developed to improve ablation outcomes and safety. The THERMOCOOL SMARTTOUCH® (ST) catheter is one of the CF-sensing catheters widely used for RFCA. The ST catheter is equipped with a technology that can measure the CF generated by the catheter tip on the myocardium and an irrigation system that cools the tip of the electrode catheter during ablation and allows high radiofrequency energy ablation without overheating at the electrode-tissue interface [3]. To enhance the cooling effects on the tip of the catheter electrode, surround flow (SF) technology was developed by equipping the catheter porous tip with 56 tiny holes, which make conduits for optimal fluid pressure distribution in the catheter tip. As the new generation of a catheter with advanced irrigation technology, the STSF catheter combines both CF and SF technologies to optimize ablation outcomes, protect cardiac function, and reduce the risk of developing eschar during ablation [4]. According to a meta-analysis of four clinical trials published before 2020, the STSF catheter was superior to the ST catheter in procedure outcomes by reducing the procedure time, fluoroscopy time, and catheter irrigation infusion volume [5]. However, this meta-analysis was unable to assess the robustness of the pooled evidence due to the small number of included studies. Additionally, this review didn't perform any analysis to address the heterogeneity and publication bias in the pooled evidence. With accumulated evidence from recently published studies assessing STSF catheter ablation in patients with AF, we conducted this systematic literature review (SLR) aiming to add more evidence from multiple sources (journals published in Chinese and recent conference proceedings) and including studies comparing STSF versus (vs.) catheters other than ST to better comprehend the values of STSF catheter for RFCA in AF patients. Thus, this SLR could be a timely evidence source to support the management of AF with catheter ablation in the countries where STSF was considered a new technology to improve ablation outcomes in AF patients.

2. Materials and Methods

This study was designed as an SLR using major English- and Chinese-language bibliographic databases to identify published, peer-reviewed clinical studies comparing the STSF catheter against other ablation catheters for procedural characteristics and clinical outcomes associated with RFCA in AF patients. This SLR was reported by following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) 2020 Statement [6].

2.1 Study eligibility criteria

This SLR set both inclusion and exclusion criteria to identify randomized clinical trials or observational studies (retrospective or prospective cohort studies) comparing the STSF catheter with other ablation catheters for AF. The study inclusion criteria are as follows: (1) including AF patients who underwent RFCA; (2) assessing STSF against any other type of ablation catheter for RFCA in adult patients with AF; (3) reporting procedural characteristics and clinical outcomes associated with ablation catheter during and/after RFCA in AF patients; and (4) designed as a clinical trial or observational study. The exclusion criteria of this SLR are as follows: (1) 60 83 preclinical (in vivo or in vitro) studies, case studies, case reports, non-original research articles (e.g.

correspondence, editorials, commentaries, overviews, summaries, communications, consensus guidelines) and reviews; (2) any cohort that includes patients with ablation for arrhythmias other than AF; (3) single-arm studies assessing STSF without control; (4) inadequate information.

2.2 Information sources and search strategies

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Given that RFCA has been implemented for AF treatment for over 20 years in China, many clinical studies 88 89 assessing various ablation catheters for AF have been published in Chinese clinical journals. Therefore, this SLR 90 explored major English bibliographic databases (MEDLINE, Embase, Web of Science, and the Cochrane Library) 91 and three major Chinese bibliographic databases (WANFANG, VIP, and China National Knowledge Infrastructure) 92 as the data sources. To align with the time of STSF approval in 2016, the literature search period was set from 93 January 1, 2016, to the date when the literature search was first conducted (July 31, 2022). Grev literature search 94 was conducted by searching the proceedings of the Heart Rhythm Society annual conference, the Society for 95 Cardiovascular Angiography and Interventions annual conference, the European Heart Rhythm Association annual 96 conference, and the Asia Pacific Heart Rhythm Society annual conference in 2021 and 2022 for any relevant but 97 not fully published studies. The trial registry databases, including ClinicalTrials.gov, European Union Clinical 98 Trials Register, and International Clinical Trials Registry Platform, were searched as well for any missing studies. 99 To ensure that all relevant evidence is captured, this study only combined the keywords for AF and STSF to 30 1 0 0 develop the search strategy for each bibliographic database and grey literature search. Search strategies is shown in 32 ¹⁰¹ Supplementary Table 1.

34102 2.3 Literature selection process

36 37 103 Two reviewers conducted the literature selection independently after which the search hits were pooled. Then, 38 104 they deleted duplicate results and identified additional studies from the left references for further eligibility 40¹⁰⁵ assessment, which included the exclusion of irrelevant references and retrieving full publications of the relevant 41 106 references. The source references reporting relevant outcome information from clinical guidelines, literature 43¹⁰⁷ review, and health economic research were cross checked with the identified references to avoid missing studies. 44 108 The developed inclusion and exclusion criteria were used to determine the study eligibility after a full publication 46 109 review. The exclusion reasons during the literature selection process were documented for records. Any 110 disagreement on study eligibility between the two reviewers was resolved by consulting with the study lead.

50 ¹¹¹ 2.4 Data collection process

52112 Excel-based data extraction forms were developed specifically to guide the data collection from the full 53 54 113 publications of included studies. The designed data extraction form was tested using one included study to align 55114 with definitions of the planned data items for extraction. Two reviewers were fully trained on how to use the data 56 57 115 extraction forms and the definitions of data items. The two reviewers conducted data extraction independently. The 58₁₁₆ extracted information from the two reviewers was further cross-checked by the third reviewer, which corrected any 59 60117 inconsistent information by verifying the information source. The study lead reviewed all extracted information for

any abnormal information before evidence synthesis.

The full publication of the included studies was reviewed to collect the following information: (1) study characteristics such as country setting, study design, and patient inclusion and exclusion criteria; (2) study arm information including the arm definition, sample size, and patient baseline characteristics (demographics, AFrelated clinical characteristics, and comorbidities); (3) ablation catheter type; (4) outcome measures that included procedural characteristics (procedure time, ablation time, fluoroscopy time, irrigation fluid volume), clinical outcomes (acute procedural success of pulmonary vein isolation (PVI), one-year post-ablation cardiac arrhythmia recurrence, ablation-related complications); and other relevant outcomes (eschar, use of diuretics, and use of urinary catheter). Most of the included studies didn't provide adequate information for the definitions of outcome measures except catheter irrigation fluid volume, fluoroscopy time, and acute procedural success of PVI.

29 2.6 Study risk of bias assessment

This SLR used Newcastle-Ottawa Scale (NOS) [7] to assess the study quality of the included studies. Based on the recommendation from previous research [8], this SLR classified included studies as good quality (NOS 8-9), fair quality (NOS 5-7), and poor quality (NOS 0-4). This SLR included one randomized clinical trial, which was published as a conference abstract and didn't provide adequate information for the quality assessment using the Jadad score [9]. Two reviewers used NOS to assess the fully published studies independently. Any disagreement on assessment was discussed with the study lead to reach a consensus.

36 2.7 Effect measures

This SLR extracted any reported effect measures from the included studies. The extracted effect measures were standardized according to their original definitions in the included studies and the selected effect measures for evidence synthesis included procedural characteristics and clinical outcomes. This SLR used weighted mean difference (WMD) to present the pooled procedural characteristics for the comparisons of procedure time, ablation time, fluoroscopy time, and catheter irrigation fluid volume. The pooled clinical outcomes for the comparisons of acute procedural success of PVI, one-year post-ablation arrhythmia recurrence, and RFCA-related overall complications were presented with a rate ratio (RR).

44 2.8 Synthesis methods

The extracted data were standardized and categorized by AF types (paroxysmal AF, persistent AF, and unspecified AF); control catheter types (ST, SF, CELSIUS[®] catheter, DiamondTempTM, and NAVISTAR[®]); patient characteristics [age, gender distribution, AF type distribution, disease duration after the diagnosis of AF, left ventricular ejection fraction (LVEF), left atrium diameter, CHA₂DS₂ VASc, and comorbidities]; and effect measures for RFCA procedural characteristics and clinical outcomes. The reported outcomes from the included studies comparing STSF vs. the same control catheter were first pooled for evidence synthesis using a pairwise Enseignement Superieur (ABES) Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies

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151 meta-analysis method, which used a random-effect model to consider the variance between the included studies and 152 within each included study. Heterogeneity in the conducted meta-analysis was assessed using the I^2 method. The 153 included studies were stratified by AF type for subgroup analysis if the heterogeneity in the pooled outcomes was 154 significant. Further exploration of potential heterogeneity sources was conducted by excluding the studies reporting 10155 different patient characteristics if significant heterogeneity was still detected in the pooled outcomes from the 11 156 subgroup analysis. The leave-one-out sensitivity analysis was conducted to determine the robustness of the overall pooled outcomes for the meta-analysis including 3 or more eligible results. The Egger's test was also performed to 13157 158 assess publication bias for overall pooled outcomes from 10 or more eligible results. This SLR used the statistical 16159 software R to conduct the described analyses. Original results from included studies were reported when the meta-18¹⁶⁰ analysis was not feasible.

3. Results 20161

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22 162 3.1 Study selection

25 ¹⁶³ This study initially identified 373 unique references from the search of the included English and Chinese 26 164 bibliographic databases. One-hundred-eighty-two were excluded due to irrelevance following the review of the 28 165 titles and abstracts of the initial batch of papers. Following the study eligibility assessment of the full publications ²⁹ 166 of the remaining 191 papers, 25 met the inclusion criteria. The search of conference proceedings and review articles identified two additional eligible studies. Thus, a total of 27 studies are included in our SLR. The flowchart of the 31 167 168 study identification process is illustrated in Figure 1.

35 169 3.2 Characteristics and qualities of included studies

37 170 The included 27 studies assessed the procedural characteristics and clinical outcomes associated with STSF 38 39 1 7 1 relative to ST (in 19 studies), SF (in 4 studies), and other four non-STSF/SF catheters (1 study for each non-⁴⁰ 172 STSF/SF catheter), respectively. This SLR only included one randomized clinical trial and the rest of the included 41 42173 studies were observational studies, including 13 retrospective studies and 13 prospective studies. This SLR دہ 174 44 included 4 studies published in Chinese. The studies published in English included 3 studies from the United States, 45 175 13 studies from Europe, and 7 studies from other regions. Among the included studies, 17 studies were fully 46 47 ¹⁷⁶ published and 10 studies were published in conference proceedings. Even though all these studies included patients 48 177 who underwent RFCA for AF, 7 studies solely included patients with paroxysmal AF, 1 study only included 49 **50**178 patients with persistent AF, and 19 studies included patients with either paroxysmal or persistent AF. According to 51 179 the reported patient baseline characteristics in these included studies, the study patients were characterized with 52 53 180 relatively old age (mean age range: 58.0-67.5 years), high CHA₂DS₂ VASc score (mean range: 1.3-2.7), and 54 181 55 prevalent cardiovascular comorbidities, which included hypertension (30.4%-98.0%), coronary heart disease 56182 (8.3%-29.2%), and heart failure (17.8%-41.7%). Of the 17 studies assessed for study quality, 7 studies had good 57 57 58¹⁸³ quality and 10 studies had fair quality. The study characteristics and main extracted information from these 59184 included 27 studies are summarized in Supplementary Table 2. 60

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3.3 Synthesized evidence from the included studies comparing the STSF catheter with the ST catheter

Of the included 19 studies comparing STSF with ST, 13 studies [10-22] included patients with unspecified AF (persistent or paroxysmal AF) and 6 studies [23-28] included patients with paroxysmal AF. The synthesized outcomes included procedural characteristics (procedure time, ablation time, fluoroscopy time, and irrigation fluid volume), primary clinical outcomes (acute procedural success of PVI, one-year post-ablation arrhythmia recurrence, and overall complications), and other ablation-related clinical outcomes that included foley catheter use, diuretics use, and eschar development.

92 3.3.1 Procedural characteristics - Procedure time

Overall, nine included studies with 10 eligible results [10-15, 23-25] report RFCA procedure time (876 operated with STSF and 762 operated with ST). The overall pooled outcomes from nine included studies showed that STSF was associated with significantly shorter procedure time than ST (WMD: -17.4 minutes, 95% CI: -25.3 to -9.4 minutes, p<0.01); however, this pooled outcome has considerable heterogeneity [I² = 76%, p<0.01]. The pooled outcomes from the stratified studies by AF types identified significantly shorter procedure time associated with the STSF catheter from the studies with unspecified AF patients (WMD: -18.7 minutes, 95% CI: -27.6 to -9.7 minutes, p<0.001) but not from the studies with paroxysmal AF patients (WMD: -14.7 minutes, 95% CI: -32.3 to 2.9 minutes, p=0.101). Because the heterogeneity of the pooled evidence from the 6 studies with unspecified AF patients was still significant, we reviewed these six studies to further explore the potential heterogeneity sources.

We found that 2 studies [10, 11] and a subgroup within one study [12] included patients who were likely to be different from those in other studies in AF duration, left atrial diameter/volume, the proportion of patients with paroxysmal AF, and proportion of patients with cardiomyopathy. After excluding the results from these four studies in the meta-analysis, the shorter procedure time of the STSF catheter remained statistically significant (WMD: -25.9 minutes, 95% CI: -33.0 to -18.8 minutes, p<0.001) with non-significant heterogeneity (I²=21%, p=0.29), suggesting that these characteristics are potential heterogeneity sources.

The leave-one-out sensitivity analysis indicated that the point estimation of the overall pooled difference in procedure time between the STSF catheter and the ST catheter had a relatively narrow range (from -15.2 minutes to -19.9 minutes). In addition, Egger's test did not detect significant publication bias for the reported difference in procedure time between the STSF catheter and the ST catheter from the included 9 studies (p=0.768). The pooled difference in the procedure time between the STSF catheter and the ST catheter is illustrated in Figure 2. The other reported outcomes are listed in Supplementary Figure 1 and Supplementary Figure 2Files.

214 3.3.2 Procedural characteristics - Ablation time

Twelve included studies [10-17, 23-26] with 13 eligible results reported the ablation time associated with using STSF and ST to conduct RFCA in 1,870 patients with AF (992 operated with STSF and 878 with ST). The pooled differences in the ablation time of the two catheters favored the STSF catheter (WMD: -6.6 minutes, 95% CI: -12.5 to -0.6 minutes, p=0.031) with significant heterogeneity (I²=98%, p<0.01). To control the potential

219 heterogeneity associated with AF type, this SLR performed a subgroup meta-analysis for this outcome by including 220 the stratified studies by the AF types of study patients (paroxysmal AF vs. unspecified AF). The pooled difference 221 in ablation time between the two catheters remained significant in the meta-analysis of the studies with unspecified 222 AF patients (WMD: -8.6 minutes, 95% CI: -16.9 to -0.4 minutes, p=0.039) but was not for the studies with 10 223 paroxysmal AF patients (WMD: -1.1 minutes, 95% CI: -4.8 to 2.6 minutes, p=0.555). However, heterogeneity in 11 224 the subgroup meta-analysis of the studies with unspecified AF patients was still significant ($I^2=98\%$, p<0.01) and 13 2 2 5 brought our attention to further explore the potential heterogeneity sources in these studies. By reviewing the 14 15²²⁶ reported patient baseline characteristics from these included studies, we found 4 studies [10-12, 16] with obviously 16227 different patient characteristics (AF duration, left atrial diameter/volume, the proportion of paroxysmal AF, 17 18²²⁸ proportion of patients with myopathy, Ablation Index value, baseline CHA₂DS₂ VASc score, saline flow rate) from 19229 the other studies. After excluding these four studies from the subgroup meta-analysis, the pooled difference in 20 21 ²³⁰ ablation time still favored the STSF catheter with statistical significance (WMD: -22.5 minutes, 95% CI: -24.3 to -22 231 20.6 minutes, p < 0.001) and low-level of heterogeneity (I²=0%, p=0.69), suggesting that these characteristics are 23 24 232 potential heterogeneity sources.

²⁵ ₂₃₃ ₂₆ The overall pooled difference in ablation time between the two catheters from the leave-one-out sensitivity 27 2 34 analysis ranged from -7.5 minutes to -5.1 minutes. No significant publication bias was detected from the included ²⁸ 29²³⁵ 12 studies comparing the two catheters for ablation time during RFCA (Egger's test: p=0.450). The pooled 30 2 36 difference in the ablation time between the STSF catheter and the ST catheter is illustrated in Figure 3. The other 31 32²³⁷ reported outcomes are listed in <u>Supplementary Figure 3 and Supplementary Figure 4</u>

34 2 38 3.3.3 Procedural characteristics - Irrigation fluid volume

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³⁶239 Six included studies [10-12, 23-25] with 1229 AF patients (629 operated with STSF and 600 with ST) 37 38 2 4 0 reported catheter irrigation fluid volume during RFCA. The meta-analysis of the reported irrigation fluid volume ³⁹ 241 40 associated with the two catheters from the 6 studies indicated a significantly lower irrigation volume for using 41 2 4 2 STSF to conduct RFCA (WMD: -492.7 mL, 95% CI -646.1 to -339.3 mL, p < 0.001). However, this pooled outcome 42 43 243 was associated with significant heterogeneity ($1^2=94\%$, p<0.01). These six included studies were stratified by 44 2 4 4 patient AF type (paroxysmal AF vs. unspecified AF) to conduct a meta-analysis for the control of potential 45 46 245 heterogeneity associated with AF types. The pairwise meta-analysis of the three studies with paroxysmal AF 47 246 48 patients [23-25] confirmed the significant reduction of catheter irrigation fluid volume (WMD: -538.6 mL, 95% CI: 49 247 -621.2 to -456.1 mL, p < 0.001) with moderate but non-significant heterogeneity (I²=38%, p=0.20) for RFCA 50 248 51 conducted by STSF catheter. However, significant heterogeneity ($1^2=94\%$, p<0.01) was found for the pooled 52 2 4 9 difference in catheter irrigation fluid volume (WMD: -461.4 mL, 95% CI: -739.2 to -183.6 mL, p=0.001) between 53 54 250 the two catheters from the left three studies with unspecified AF patients [10-12]. No further exploration of 55 2 5 1 heterogeneity resources for this pooled outcome due to a limited number of studies reporting this outcome measure. 56 57 252 The overall pooled difference in catheter irrigation fluid volume between the two catheters from the leave-one-out 58253 sensitivity analysis ranged from -532.1 mL to -427.3 mL. 59

60 2 5 4 The pooled difference in the catheter irrigation fluid volume between the STSF catheter and the ST catheter is

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illustrated in Figure 4. The other reported outcomes are listed in Supplementary Figure 5iles.

3.3.4 Procedural characteristics - Fluoroscopy time

Eight included studies [10-13, 23, 25-27] compared fluoroscopy time between STSF catheter and ST catheter used to conduct RFCA (four studies [10-13] with unspecified AF patients and four studies [23, 25-27] with paroxysmal AF). The overall pooled difference in fluoroscopy time during RFCA between the two catheters showed that the STSF catheter was associated with significantly shorter fluoroscopy time than the ST catheter (WMD: -1.6 minutes, 95% CI: -2.8 to -0.3 minutes, p=0.014); however, this pooled outcome was associated with significant heterogeneity ($I^2=77\%$, p<0.014). The included studies were further stratified by the patient AF types (paroxysmal AF vs. unspecified AF) to conduct subgroup meta-analysis to explore potential heterogeneity associated with AF types. The subgroup meta-analysis including studies with paroxysmal AF patients confirmed the significantly shorter fluoroscopy time during RFCA conducted by STSF catheter (WMD: -1.4 minutes, 95% CI: -2.2 to -0.6 minutes, p < 0.001) with a low level of heterogeneity (I²=8%, p = 0.35) [23, 25-27]. However, the pooled difference in fluoroscopy time between the two catheters from the subgroup meta-analysis of 5 eligible results from the four studies with unspecified AF patients [10-13] didn't reach statistical significance and also had substantial heterogeneity. No further exploration of heterogeneity sources for this subgroup meta-analysis due to a limited number of included studies reporting this outcome. The overall pooled difference in fluoroscopy time between the two catheters from all included studies in the leave-one-out sensitivity analysis ranged from -1.9 minutes to -1.4 minutes.

The results of the meta-analysis of the included 8 studies reporting fluoroscopy time associated with STSF catheter and ST catheter are illustrated in Figure 5. The other reported outcomes are listed in Supplementary Figure <u>6</u>les.

3.3.5 Primary clinical outcomes

Thirteen studies [10-17, 22-24, 26, 28] reported primary clinical outcomes, including the acute procedural success of PVI, one-year post-ablation cardiac arrhythmia recurrence, and overall complications related to RFCA. The overall pooled RR for acute procedure success [10, 12, 14-17, 26, 28], one-year post-ablation cardiac arrhythmia recurrence [10, 13, 17, 22, 28], and overall complications [11, 14, 16, 17, 23, 24, 26, 28] from these studies were 0.995 (95% CI: 0.976 to 1.014, p=0.592), 0.727 (95% CI: 0.355 to 1.490, p=0.384), and 0.766 (95% CI: 0.299 to 1.959, p=0.578), respectively, without reaching statistical significance. Among these three pooled outcomes, only the pooled RR for one-year post-ablation arrhythmia recurrence between the two catheters was associated with significant heterogeneity (I² = 68%, p<0.01). Subgroup meta-analysis including stratified studies by patient AF types (paroxysmal AF vs. unspecified AF) was unable to homogenize the pooled RR for one-year postablation cardiac arrhythmia recurrence between the two catheters. The leave-one-out sensitivity analyses for the three pooled outcomes observed a narrow range for pooled RR for the acute procedural success of PVI (0.993 to 0.999) but wide ranges for one-year post-ablation cardiac arrhythmia recurrence (0.555 to 0.929) and overall complications (0.600 to 0.927). All reported outcomes are illustrated in Supplementary Fig<u>ure 7</u>-10.

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3.3.6 Other ablation-related clinical outcomes

Three included studies reported other ablation-related clinical outcomes. Two studies [23, 24] (502 paroxysmal AF patients) reported significantly lower utilizations of the foley catheter [RR: 0.506, 95% CI 0.393 to 0.651, p<0.001] without heterogeneity (I²=0%, p=0.68). One study [25] with 47 paroxysmal AF patients reported STSF catheter was associated with a significantly lower risk of diuretics use (RR: 0.050, 95% CI: 0.003 to 0.819, p=0.036). In addition, one study [27] with 68 paroxysmal AF patients reported that STSF catheter was associated with a reduced risk of eschar formation during ablation without reaching statistical significance (RR: 0.143, 95% CI 0.008 to 2.663, p=0.192). The pooled outcomes are illustrated in Supplementary Figure 11iles.

3.4 Synthesized evidence from the studies comparing the STSF catheter with the SF catheter

This SLR identified 4 studies [29-32] comparing STSF with SF for procedural characteristics and clinical 21 300 outcomes in AF patients. One study [29] with a small sample size (26 using STSF catheter and 26 using SF 22 301 catheter) reported significantly longer RFCA procedure time (mean difference: 20.0 minutes, 95% CI: 2.9 to 37.1 ²³₂₄ 302 minutes, p=0.022) and fluoroscopy time (mean difference: 4.0 minutes, 95% CI: 1.1 to 6.9 minutes, p=0.007) in the 25 303 STSF group. The meta-analysis including 2 studies [29, 30] with 252 patients did not identify significant differences in both acute procedure success of PVI and ablation-related complications between the two catheters. 27₃₀₅ One study [31] with 395 patients with paroxysmal AF (298 using STSF and 97 using SF) reported significantly 29³⁰⁶ shorter ablation time (mean difference: -5.7 minutes, 95% CI: -8.4 to -3.1 minutes, p < 0.001). The pooled RR for one-year post-ablation arrhythmia recurrence between the two catheters from the two studies [31, 32] favored the 31 308 STSF catheter with statistical significance (RR: 0.503, 95% CI: 0.379 to 0.667, p < 0.001, heterogeneity test: $I^2=0\%$, 33³⁰⁹ p=0.98) when compared to SF catheter. The reported RFCA-related outcomes from the four studies are summarized in Table 1. The pooled outcomes are illustrated in Supplementary Figure 12-15.

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1 2 3 4 5 6 7	311	
6 7		AF type
8 9 10 11 12 13 14		Unspecified AF
15 16 17 18 19 20 21 22		Paroxysmal AF
22 23 24 25		Persistent AF
23 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45	312	STSF: SMARTT

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	Tab	le 1. Summary of the pooled differences in RF	CA-related outc	omes between STSF cath	eter and SF cat	eter 🗓 AF pa				
			Number of		Outcome	: g	Pooled outcomes			
AF type	Outcome type	Outcome	studies	Sample size	7	est mation	95%CI lower	95%CI upper	P value	
Jnspecified AF	Procedural characteristics	Procedure time (minutes) [29]	1	STSF: 26; SF: 26	WMD F	estropation Enseigneme	2.9	37.1	0.022	
		Fluoroscopy time (minutes) [29]	1	STSF: 26; SF: 26	WMD ted	2023.	1.1	6.9	0.007	
	Clinical outcomes	Acute procedural success of PVI (%) [29]	1	STSF: 26; SF: 26	RR 6	nent Superieur (0.928	1.078	1.000	
		Any complications [29, 30]	2	STSF: 126; SF: 126	RR an	uperio 10745	0.052	10.574	0.828	
Paroxysmal AF	Procedural characteristics	Ablation time (minutes) [31]	1	STSF: 298; SF: 97	WMD oa	eur Gafr	-8.4	-3.1	<0.001	
		Radiofrequency energy use (J) [31]	1	STSF: 298; SF: 97	WMD B	Abr 32.5 	-9,629.5	-1,235.5	0.011	
	Clinical outcomes	Acute procedural success of PVI (%) [31]	1	STSF: 298; SF: 97	RR g		0.985	1.015	1.000	
		One-year post-ablation arrhythmia recurrence rate (%) [31]	1	STSF: 298; SF: 97	RR H tra		0.368	0.689	<0.001	
Persistent AF	Clinical outcomes	One-year post-ablation arrhythmia recurrence rate (%) [32]	1	STSF: 74; SF: 74		. \$500	0.262	0.956	0.036	
		Any complications [32]	1	STSF: 74; SF: 74	RR and	0	0.378	10.587	0.415	
SF: SMARTI	OUCH [®] SURROUNDFI	.OW; SF: SURROUNDFLOW; AF: Atrial fibrillation			milar technologies.	_				

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314 This SLR identified 4 studies comparing STSF with four non-ST/SF catheters which were the CELSIUS® catheter [33], DiamondTemp[™] catheter [34], DirectSense catheter guided by Rhythmia[™] System [35], and 315 NAVISTAR[®] catheter [36]. The 4 studies reported that the STSF catheter was associated with significantly shorter 316 10317 RFCA procedure time than the DiamondTemp[™] catheter(mean difference: -20.6 minutes, 95% CI: -32.5 to -8.7 12318 minutes, p<0.001) and NAVISTAR[®] catheter (mean difference: -30.0, 95% CI: -39.9 to -20.1 minutes, p<0.001); 13₃₁₉ significantly shorter ablation time than NAVISTAR® catheter (mean difference: -15.0 minutes, 95% CI: -20.5 to -15 3 2 0 9.5 minutes, p < 0.001; and significantly shorter fluoroscopy time than DirectSense catheter guided by RhythmiaTM 16 17 321 System (mean difference: -7.0 minutes, 95% CI: -10.9 to -3.1 minutes, p<0.001) and NAVISTAR® catheter (mean 18322 difference: -2.0 minutes, 95% CI: -2.8 to -1.2 minutes, p < 0.001). However, one study with 116 patients with 19 20³²³ persistent or paroxysmal AF [34] reported that the STSF catheter was associated with a significantly longer ablation 21 3 24 time than the DiamondTemp[™] catheter (mean difference: 4.1 minutes, 95% CI: 2.0 to 6.2 minutes, p<0.001). None ²²₂₃ 325 of these 4 studies reported any significant differences in the rates of ablation-related overall complications between 24 3 26 the STSF catheter and the four non-ST/SF catheters. 25

27 327 4. Discussion

28 29³²⁸ Compared to a similar SLR published in 2020 [5], our SLR was designed with an expansive search period and 30 3 2 9 search scope which has resulted in the inclusion of a larger pool of studies and much more robust evidence to 31 3 30 demonstrate the values of STSF catheter for RFCA in AF patients. For example, our SLR captured and studied 32 331 significantly more studies than the aforementioned SLR (27 studies vs. 4 studies). Additionally, not only did our 33 34³³² SLR include studies comparing STSF with ST but also with SF and other ablation catheters in AF patients; in 35 333 contrast, the other SLR only included studies comparing STSF with ST. Furthermore, our SLR synthesized 36334 evidence for more outcomes than the previous SLR and conducted additional heterogeneity analysis and 37 335 publication bias assessment to make the pooled findings more robust. Therefore, our SLR should be more 38 336 informative regarding the clinical values of STSF for RFCA in AF patients.

39 40³³⁷ 41³³⁸ According to the studies reviewed in this SLR, the STSF catheter was mainly studied in comparison with the ST catheter in AF patients. As the STSF catheter evolved from the ST catheter by upgrading the irrigation system 42 3 39 to improve procedural characteristics, the STSF catheter contains all the features of the ST catheter such as the 43 3 40 contact force technology and advanced irrigation system that provides uniform cooling at half the flow rate of ST ⁴⁴_341 catheter and facilitates the process of fluid management [4]. The pooled evidence for the outcomes that were 45 341 46 342 compared between the two catheters in our SLR aligned with the expected impact of the advanced irrigation system 47 343 of STSF. For example, the pooled evidence showed that the STSF catheter significantly save RFCA procedure time 48 3 4 4 (17.4 minutes, p < 0.001), ablation time (6.6 minutes, p = 0.031), and fluoroscopy time (1.6 minutes, p = 0.016) with 49 3 4 5 significantly reduced catheter irrigation fluid volume (492.7 mL, p<0.001) relative to ST catheter. These benefits ⁵⁰ 346 could potentially improve the performance efficiency of RFCA and enhance the capacity of conducting RFCA in 51 51 52³⁴⁷ hospital settings. The substantial reduction in the irrigation volume of STSF could substantially limit the cardiac 53 348 burden due to catheter irrigation infusion and make ablation treatment safer to treat AF with heart failure. Even 54349 though the pooled outcome for reduced fluoroscopy time was statistically significant, the estimated reduction of 55 350 fluoroscopy time by STSF in this review was unlikely to be substantial and this finding should be interpreted with 56 --- 351 caution. As a new technology, STSF could be often used with more fluoroscopy to confirm the position of catheter 57 57 58³⁵² during the learning process. With more use of STSF in real-world settings, the benefits of STSF in reducing 59353 occupational health hazards during RFCA could be better demonstrated in future studies.

60354 The pooled evidence also indicates that primary clinical outcomes, including acute procedure success of PVI,

355 one-year post-ablation arrhythmia recurrence, and overall complications, are comparable for the STSF catheter and 4 356 ST catheter. A possible explanation is that both catheters use the same contact force technology, which is the 5 357 primary driver of the ablation effects [37]. However, the advanced irrigation system of the STSF could bring more 6 358 clinical benefits to AF patients with heart failure. According to the reported patient characteristics from the 7 8 359 included studies, AF patients are characterized by old age (mean age range: 58.0-67.5 years old) and a high 9 360 prevalence of heart failure (17.8% to 41.7%). The fluid infusion through the catheter during RFCA could stress the 10 361 heart and deteriorate the cardiac function in patients with heart failure. Even though RFCA has been proven to 11 12 362 improve cardiac function (indicated by LVEF [38]), previous studies observed a high rate of developing acute heart 13 363 failure (4.9% to 26.1%) after open-irrigated catheter ablation [39-41]; the development of acute heart failure after 14364 ablation in these studies was likely due to excessive infusion fluid during ablation procedure as patients with 15 365 developed acute heart failure after ablation was associated with significantly higher net fluid infusion volume 16 17 366 during ablation than those without developing acute heart failure. Thus, the substantial reduction of the catheter 18 367 irrigation infusion volume of the STSF catheter could lower the burden of RFCA on the cardiac load and 19368 potentially reduce the risk of acute heart failure after RFCA [42]. In addition, the shortened ablation time through 20 3 6 9 STSF could make RFCA more tolerable for AF patients with heart failure who are prone to developing respiratory ²¹ ₃₇₀ ²² ₃₇₁ distress with the flat position required by the ablation procedure [43]. Since AF patients are often complicated with heart failure due to old age and other cardiovascular conditions, future research should be encouraged to confirm 24 372 the cardiac function-related benefits of STSF and generate robust evidence to inform clinical practices and 25 3 7 3 guidelines regarding the appropriate applications of STSF catheter ablation for AF. Another potential clinical 26 3 7 4 benefit of the improved irrigation system of STSF is the reduction of the risk of eschar due to the amplified cooling ²⁷ 375 28 effects. Eschar occurs more often with unipolar radiofrequency ablation that generates excessive local temperature 28 29³⁷⁶ leading to the formation of eschar on the tissue surface; carbonization; and thromboembolic complications; and 30 377 even damage to the esophagus and atrium, which induces serious complications such as atrial esophageal fistula, 31 378 atrial rupture, and pulmonary vein stenosis [44]. Because the STSF catheter has a more advanced irrigation system 32 379 than the ST catheter, it is expected that the STSF catheter could be associated with a lower risk of eschar formation ³³₃₈₀ 34 than the ST catheter. However, this SLT didn't identify robust evidence to support this clinical benefit of STSF as 35⁴381 only one study with a small sample size reported a non-significant trend for the reduced risk of eschar for STSF 36382 catheter [27].

37 383 This SLR also identified 4 eligible studies comparing the STSF catheter with SF catheter and other 4 studies 38 384 comparing the STSF catheter with non-ST/SF catheters. The pooled evidence from two eligible studies identified 39 40 41 386 significantly reduced one-year post-ablation arrhythmia recurrence for STSF catheter relative to SF catheter. Because these SF catheters were equipped with a similar irrigation technology as the STSF catheter but without 42 387 contact force technology, which mainly drives the ablation outcomes [37]. The reported outcomes from the four 43 388 studies comparing the STSF catheter with contemporary non-ST/SF catheters suggested that the STSF catheter 44 389 could be better than the non-ST/SF catheter regarding the procedure characteristics, which included procedural 45 46 47 390 47 391 time, ablation time, and fluoroscopy time. However, these findings are not robust due to a limited number of studies (only one study comparing STSF with each non-ST/SF catheter) and the small sample size in each included study.

48 392 The generated evidence from this SLR should be interpreted with caution as most of the included studies were 49 3 9 3 observational studies (26 observational studies and one randomized clinical trial) and the reported outcomes from 50 394 the included studies were not pooled separately by study design. Thus, the pooled evidence in our review is likely 51 52 53 395 53 396 to have the common limitations of observational studies that include bias, measurement bias, and unknown confounders. These limitations could introduce heterogeneity in the pooled evidence in our review. Additionally, 54 3 97 the included studies with small sample size could further introduce heterogeneity. That might explain why most of 55 398 the overall pooled outcomes in this SLR had significant heterogeneity. This SLR did recognize that AF type could 56 399 an important heterogeneity source as the persistent AF usually requires additional substrate ablation beyond PVI 57 58 400 than paroxysmal AF. Thus, this SLR stratified the included studies by patient AF types to control heterogeneity in 59 401 the pooled outcomes. This strategy seems to work well in reducing heterogeneity in the pooled outcomes from the 60 4 0 2 studies only including paroxysmal AF patients. Due to insufficient studies, this SLR only tried to explore

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heterogeneity resources for procedure time and ablation time by further excluding studies with obviously different 404 patient characteristics rather than conducting meta-regression analyses. The lack of definitions for some outcome 405 measures in the included studies could introduce measurement bias and further increase the heterogeneity in the 406 pooled evidence. In addition, this SLR doesn't have enough studies to explore the heterogeneity sources in other 407 pooled outcomes. For the same reason, this SLR only assessed the publication bias for RFCA procedure time and 408 ablation time. Given the fact that most of the included studies compared the STSF catheter with the ST catheter, the 10 409 pooled evidence regarding the comparisons between STSF with non-ST catheters was not robust enough. Thus, this 11 12⁴¹⁰ SLR didn't grade the pooled evidence because of the limitations discussed above. Future research with adequate 13411 quality is still needed to confirm the generated evidence from this SLR and further explore the potential clinical 14412 benefits of using the STSF catheter to conduct RFCA for AF (such as preventing eschar and acute heart failure). 15413 In summary, this SLR demonstrated that STSF is superior to ST catheter by reducing procedure time, ablation 16 17⁴¹⁴ time, fluoroscopy time, and irrigation fluid volume. Because both catheters use contact force technology which is a 18415 key factor in determining ablation outcomes, it is not a surprise to see highly comparable acute procedure success 19416 of PVI and one-year post-ablation arrhythmia recurrence between STSF catheter and ST catheter from the pooled 20417 evidence. Due to the lack of sufficient and robust evidence to support other clinical benefits of the STSF catheter ²¹418 relative to other catheters, such as preventing eschar and acute heart failure, more future studies with appropriate 22 23⁴¹⁰ 23 study designs and sufficient sample size are needed in this field. 24 25 4 20 5. Figures 26 Figure 1. Literature search flowchart for identifying eligible studies (STSF: SMARTTOUCH® 27 4 2 1 28422 SURROUNDFLOW; ST: THERMOCOOL SMARTTOUCH®; SF: SURROUNDFLOW; AF: Atrial fibrillation). ²⁹423 Figure 2. Forest plot for the paired meta-analysis of the included studies for the difference in RFCA procedure 30 31⁴²³ 31 time (minutes) between STSF catheter and ST catheter (STSF: SMARTTOUCH® SURROUNDFLOW; ST: 32 425 THERMOCOOL SMARTTOUCH®; AF: Atrial fibrillation; SD: Standard deviation; WMD: Weighted mean 33 4 2 6 difference; CI: Confidence interval). 34 4 27 Figure 3. Forest plot for the paired meta-analysis of the included studies for the difference in ablation time ³⁵428 (minutes) between STSF catheter and ST catheter (STSF: SMARTTOUCH® SURROUNDFLOW; ST: 36⁴²⁸ 37⁴²⁹ THERMOCOOL SMARTTOUCH®; AF: Atrial fibrillation; SD: Standard deviation; WMD: Weighted mean 38 4 30 difference; CI: Confidence interval). 39431 Figure 4. Forest plot for the paired meta-analysis of the included studies for the difference in catheter irrigation 40 4 3 2 fluid volume (mL) between STSF catheter and ST catheter for RFCA (STSF: SMARTTOUCH® 41 433 42 424 SURROUNDFLOW; ST: THERMOCOOL SMARTTOUCH®; AF: Atrial fibrillation; SD: Standard deviation; 42 43⁴³⁴ WMD: Weighted mean difference; CI: Confidence interval). 44 435 Figure 5. Forest plot for the paired meta-analysis of the included studies for the difference in fluoroscopy time 45 4 3 6 between STSF catheter and ST catheter for RFCA (STSF: SMARTTOUCH® SURROUNDFLOW; ST: 46 4 37 THERMOCOOL SMARTTOUCH®; AF: Atrial fibrillation; SD: Standard deviation; WMD: Weighted mean 47 48 48 difference; CI: Confidence interval) 49⁴³⁹ 50 Acknowledgment 51 4 4 0 52 53₄₄₁ Patients and or the public were not involved in this study. 54 55 56 442 **Conflict of Interest** 57 58 4 4 3 Liang Tan and Wendong Chen are employed by contract research organizations that receive industry funds to 59444 conduct health economics and outcomes research. Other authors declare that the research was conducted in the 60 4 4 5 absence of any commercial or financial relationships that could be construed as a potential conflict of interest. 1 For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

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448 Availability of Data and Materials

Data sharing is not applicable to this article, as no datasets were generated or analyzed during the current study.

14451 **Contributions Statement**

16452 Jianyong Li, Guifang Zhou, Yuegang Wang, and Xiaobo Huang formulated the research idea. Jianyong Li, ¹⁷453 Guifang Zhou, Xinzhong Li, Senlin Huang, Yuegang Wang, Xiaobo Huang, Liang Tan, and Wendong Chen 19⁴⁵⁴ developed the study protocol. Jianyong Li, Guifang Zhou, Xinzhong Li, Senlin Huang, Hairuo Lin, Shaopeng Lin, 20455 and Liang Tan conducted the literature search, study quality assessment, data extraction, and evidence synthesis. 21 4 5 6 Jianvong Li, Guifang Zhou, Xinzhong Li, Senlin Huang, Xiaobo Huang, Yuegang Wang, and Wendong Chen 22 4 57 drafted the manuscript based on the study findings. All authors contributed to editorial changes in the manuscript. ²³/₄₅₈ All authors read and approved the final manuscript.

26 ⁴⁵⁹ **Ethics Approval and Consent to Participate**

Not applicable.

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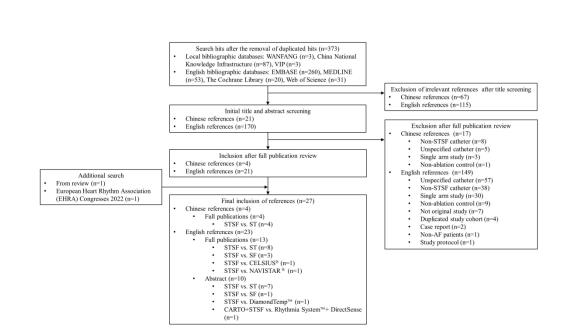


Figure 1. Literature search flowchart for identifying eligible studies (STSF: SMARTTOUCH® SURROUNDFLOW; ST: THERMOCOOL SMARTTOUCH®; SF: SURROUNDFLOW; AF: Atrial fibrillation).

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Study		STSF			ST		Before heterogeneity control	After heterogeneity control
Study	Total	Mean	SD	Total	Mean	SD	Weighted Mean Difference	Weighted Mean Difference
Unspecified AF								
Zhou 2021[13]	142	96.4	31.6	98	119.5	33.8	- 	
Lee 2019b [14]	39	168.0	34.0	32	199.0	42.0		
Lee 2019a [15]	66	160.0	37.0	32	199.0	42.0		
Solimene 2019 (Subgroup 2)[12]	151	125.0	73.0	81	144.0	44.0		
Maurer 2018[10]	75	131.3	33.7	35	133.0	42.0		
Plenge 2020 [11]	60	106.3	28.4	20	116.7	26.7		
Solimene 2019 (Subgroup 1)[12	162	120.0	72.0	96	129.0	44.0		
	695			394				-
Heterogeneity: $I^2 = 62\%$, $\tau^2 = 92.0$	031, p =	0.01						21%, τ ² = 6.9084, p = 0.29
							-40 -20 0 20 40	-40 -20 0 20
Random effects model	meta-a	nalysis	result				WMD: -18.7, 95% CI: -27.6 to -9.7, p<0.001	WMD: -25.9, 95% CI: -33.0 to -18.8, p<0.0
Paroxysmal AF							:	
Melby 2018[23]	71	114.0	30.0	102	114.0	24.0		
Duvtschaever 2019[24]	86	137.4	30.1	243	162.9	36.9		
Chopra 2018[25]	24	192.7	46.0	23	213.9	43.5		
enopia 2010()								
Random effects model	181			368				
Heterogeneity: $I^2 = 90\%$, $\tau^2 = 189$.	7783. p	< 0.01					-40 -20 0 20 40	
							-40 -20 0 20 40	
Random effects model	meta-a	nalysis	result				WMD: -14.7, 95% CI: -32.3 to 2.9, p=0.101	
Overall								
Random effects model	876			762			\$	
		< 0.01						
Heterogeneity: $I^2 = 76\%$, $\tau^2 = 111$.							-40 -20 0 20 40	

Figure 2. Forest plot for the paired meta-analysis of the included studies for the difference in RFCA procedure time (minutes) between STSF catheter and ST catheter (STSF: SMARTTOUCH® SURROUNDFLOW; ST: THERMOCOOL SMARTTOUCH®; AF: Atrial fibrillation; SD: Standard deviation; WMD: Weighted mean difference; CI: Confidence interval).

303x155mm (300 x 300 DPI)

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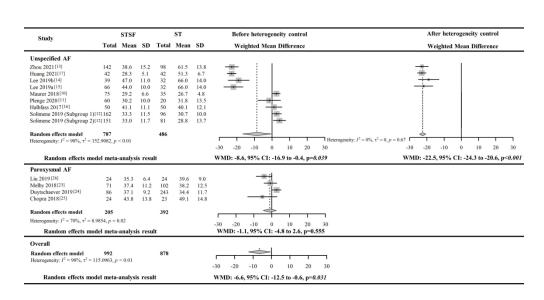


Figure 3. Forest plot for the paired meta-analysis of the included studies for the difference in ablation time (minutes) between STSF catheter and ST catheter (STSF: SMARTTOUCH® SURROUNDFLOW; ST: THERMOCOOL SMARTTOUCH®; AF: Atrial fibrillation; SD: Standard deviation; WMD: Weighted mean difference; CI: Confidence interval).

311x163mm (300 x 300 DPI)

Study		STSF			ST		Weighted Mean Difference				
Study	Total Mean SD			Total Mean		SD		Weighten 1	vican Di	nerence	
Unspecified AF											
Maurer 2018[10]	75	265.5	64.4	35	539.6	118.2		: •	1		
Plenge 2020 [11]	60	241.4	79.6	20	540.3	229.5			.		
Solimene 2019 (Subgroup 1)	[12]162	701.0	287.0	96	1105.0	573.0					
Solimene 2019 (Subgroup 2)	[12]151	836.0	503.0	81	1732.0	664.0		- [
Random effects model Heterogeneity: $I^2 = 94\%$, $\tau^2 = 7$	448	n < 0.01		232				\sim	-		_
Heterogeneity: $I = 94\%$, $\tau = 7$	6833.3378,	p < 0.01					-1000	-500	0	500	1000
Random effects mode	l meta-ar	nalysis r	esult				WMD: -46	1.4, 95% (CI: -739.	2 to -183.0	6, p=0.001
Paroxysmal AF											
Melby 2018[23]	71	563.0	168.0	102	1145.0	375.0		÷.	1		
Duytschaever 2019[24]	86	785.3	356.0	243	1255.6	469.3		÷			
Chopra 2018 [25]	24	697.3	299.3	23	1277.0	315.8	-				
Random effects model	181			368							
				308					_		
Heterogeneity: $I^2 = 38\%$, $\tau^2 = 2$	2229.0153,	p = 0.20					-1000	-500	0	500	1000
Random effects mode	l meta-ar	nalysis r	esult			v		8.6, 95% C			
Overall											-
Random effects model	629			600				$\dot{\langle}$	1		
Heterogeneity: $I^2 = 94\%$, $\tau^2 = 3$		p < 0.01		500				Ť		1	
		, p . 0.01					-1000	-500	0	500	1000
Random effects model meta-analysis result WMD: -492.7, 5								7 059/ 6	T. (1(1	4- 220.2	

Figure 4. Forest plot for the paired meta-analysis of the included studies for the difference in catheter irrigation fluid volume (mL) between STSF catheter and ST catheter for RFCA (STSF: SMARTTOUCH® SURROUNDFLOW; ST: THERMOCOOL SMARTTOUCH®; AF: Atrial fibrillation; SD: Standard deviation; WMD: Weighted mean difference; CI: Confidence interval).

203x140mm (300 x 300 DPI)

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Study		STSF S							
Study	Total	Mean	Mean SD		Total Mean		Weighted Mean Difference		
Unspecified AF									
Maurer 2018 [10]	75	14.0	6.0	35	13.5	6.6			
Zhou 2021[13]	142	15.3	3.3	98	16.9	3.6			
Plenge 2020[11]	60	16.0	6.7	20	13.8	5.7	· · · · ·		
Solimene 2019 (Subgroup 1)	[12] 162	4.3	5.9	96	9.0	4.8	:		
Solimene 2019 (Subgroup 2)		6.3	7.6	81	9.0	6.9			
Random effects model	590			330					
Heterogeneity: $I^2 = 86\%$, $\tau^2 = 5$		0.01		000					
	,, , , , , , , , , , , , , , , , , , ,						-6 -4 -2 0 2 4 6		
Random effects mode	l meta-ar	alysis r	esult				WMD: -1.5, 95% CI: -3.8 to 0.8, p=0.201		
Paroxysmal AF									
Zhang 2020[27]	34	11.3	2.9	34	12.3	3.3			
Liu 2019 [26]	24	7.8	3.1	24	11.2	6.3			
Melby 2018 [23]	71	3.1	4.4	102	4.7	2.7			
Chopra 2018[25]	24	8.5	3.9	23	8.7	4.6			
Random effects model	153			183			\diamond		
Heterogeneity: $I^2 = 8\%$, $\tau^2 < 0$.0001, <i>p</i> =	0.35							
							-6 -4 -2 0 2 4 6		
Dandam offects mode	l meta-ar	alysis r	esult				WMD: -1.4, 95% CI: -2.2 to -0.6, p<0.001		
Random effects mode									
Overall									
Overall	743			513					
Overall Random effects model	/	0.01		513					
	/	0.01		513					

Figure 5. Forest plot for the paired meta-analysis of the included studies for the difference in fluoroscopy time between STSF catheter and ST catheter for RFCA (STSF: SMARTTOUCH® SURROUNDFLOW; ST: THERMOCOOL SMARTTOUCH®; AF: Atrial fibrillation; SD: Standard deviation; WMD: Weighted mean difference; CI: Confidence interval)

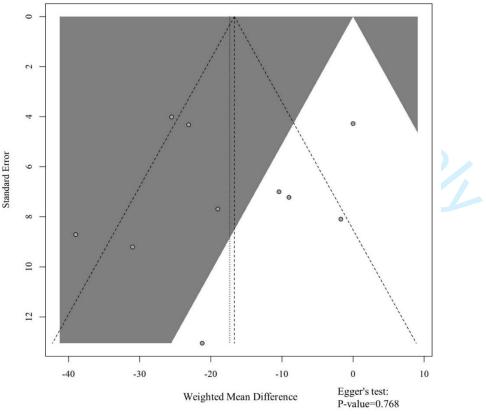
192x147mm (300 x 300 DPI)

Supplementary Figures

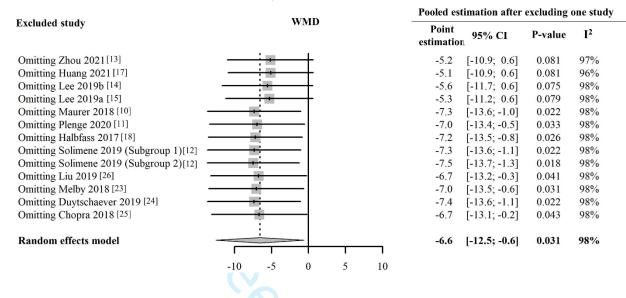
Supplementary Figure 1. Forest plot of the leave-one-out sensitivity analysis for pooled difference in RFCA procedure time (minutes) between STSF catheter and ST catheter (WMD: Weighted mean difference; CI: Confidence interval).

	WMD		Pooled estimation after excluding one study				
Excluded study	WMD		Point estimatio	95% CI	P-value	I ²	
Omitting Zhou 2021 [13]	——————————————————————————————————————		-16.6	[-25.5; -7.7]	< 0.001	76%	
Omitting Lee 2019b [14]			-16.1	[-24.4; -7.9]	< 0.001	77%	
Omitting Lee 2019a[15]			-15.2	[-22.8; -7.7]	< 0.001	73%	
Omitting Solimene 2019 (Subgroup 2)[12]			-17.2	[-26.0; -8.4]	< 0.001	78%	
Omitting Maurer 2018[10]			-18.9	[-27.1; -10.8]	< 0.001	76%	
Omitting Plenge 2020[11]			-18.2	[-26.9; -9.5]	< 0.001	78%	
Omitting Solimene 2019 (Subgroup 1)[12]			-18.3	[-27.0; -9.7]	< 0.001	77%	
Omitting Melby 2018 [23]			-19.9	[-27.0; -12.8]	< 0.001	55%	
Omitting Duytschaever 2019 [24]			-16.2	[-24.9; -7.5]	< 0.001	74%	
Omitting Chopra 2018[25]			-17.1	[-25.6; -8.7]	< 0.001	78%	
Random effects model			-17.4	[-25.3; -9.4]	< 0.001	76%	
	-20 -10 0	10 20					

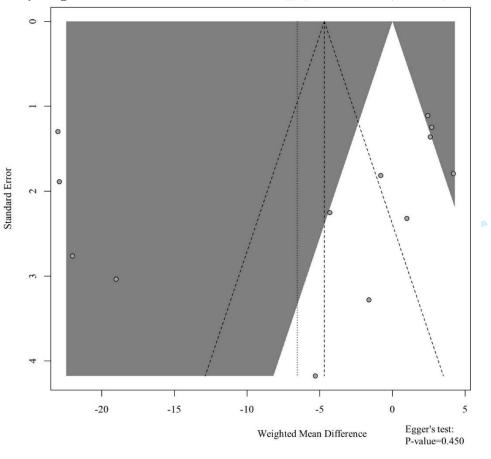
Supplementary Figure 2. Illustrated publication bias analysis for the included studies comparing STSF catheter with ST catheter for RFCA procedure time (minutes).



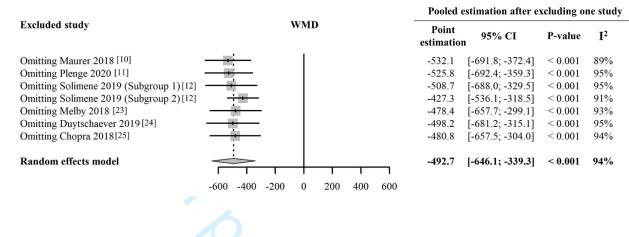
Supplementary Figure 3. Forest plot of the leave-one-out sensitivity analysis for pooled difference in ablation time (minutes) between STSF catheter and ST catheter (WMD: Weighted mean difference; CI: Confidence interval).



Supplementary Figure 4. Illustrated publication bias analysis for the included studies comparing STSF catheter with ST catheter for ablation time (minutes).



Supplementary Figure 5. Forest plot of the leave-one-out sensitivity analysis for pooled difference in irrigation fluid volume (mL) during RFCA between STSF catheter and ST catheter (WMD: Weighted mean difference; CI: Confidence interval).



Supplementary Figure 6. Forest plot of the sensitivity analysis for pooled difference in fluoroscopy time (minutes) during RFCA between STSF and ST (WMD: Weighted mean difference; CI: Confidence interval).

		Pooled estimation after excluding one study					
Excluded study	WMD	Point estimation	95% CI	P-value	I ²		
Omitting Maurer 2018 ^[10]	I	-1.8	[-3.1; -0.5]	0.007	77%		
Omitting Zhou 2021 ^[13]	i	-1.5	[-3.0; -0.1]	0.042	79%		
Omitting Plenge 2020 ^[11]		-1.9	[-3.1; -0.8]	0.001	74%		
Omitting Solimene 2019 (Subgroup 1)[12]		-1.4	[-1.9; -0.8]	< 0.001	45%		
Omitting Solimene 2019 (Subgroup 2)[12]		-1.4	[-2.8; -0.0]	0.050	79%		
Omitting Zhang 2020 [27]		-1.6	[-3.1; -0.2]	0.027	78%		
Omitting Liu 2019 [26]		-1.4	[-2.7; -0.0]	0.044	79%		
Omitting Melby 2018 [23]		-1.5	[-3.0; -0.1]	0.041	79%		
Omitting Chopra 2018 [25]		-1.7	[-3.1; -0.3]	0.014	78%		
Random effects model		-1.6	[-2.8; -0.3]	0.014	77%		
	-3 -2 -1 0 1 2	3					

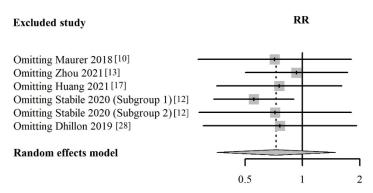
Supplementary Figure 7. Forest plot for the paired meta-analysis of the included studies comparing STSF vs. ST for acute procedural success of PVI (STSF: SMARTTOUCH[®] SURROUNDFLOW; ST: THERMOCOOL SMARTTOUCH[®]; AF: Atrial fibrillation; RR: Rate ratio; CI: Confidence interval).

Study	ST	SF	S	T	
	Events	Total	Events	Total	Rate Ratio
Unspecified AF					
Maurer 2018 [10]	75	75	35	35	+
Huang 2021 [17]	42	42	42	42	+
Halbfass 2017 [16]	50	50	50	50	÷
Lee 2019b [14]	37	39	31	32	<u>_</u>
Lee 2019a [15]	64	66	31	32	-
Solimene 2019 (Subgroup 1)[12]	153	162	94	96	-
Solimene 2019 (Subgroup 2)[12]	139	151	77	81	
Random effects model		585		368	
Heterogeneity: $I^2 = 0\%$, $\tau^2 = 0$, $p =$	0.95	000		000	
	0.50				0.75 1 1.5 2
Random effects model me	ta-analy	sis resu	ılt		RR: 0.993, 95% CI: 0.974 to 1.013, p=0.50
Paroxysmal AF					
Liu 2019 [26]	24	24	24	24	- ;
Dhillon 2019 [28]	34	50	24	50	
	51	50	21	50	_
Random effects model		74		74	
Heterogeneity: $I^2 = 73\%$, $\tau^2 = 0.04$	13 n = 0			/ -	
Therefore the second s	+3, p = 0	.05			0.75 1 1.5 2
Random effects model me	ta-analy	sis resu	ılt		RR: 1.141, 95% CI: 0.819 to 1.589, p=0.43
Overall					
Random effects model		659		442	\$
Heterogeneity: $I^2 = 0\%$, $\tau^2 < 0.0001$	p = 0.63	8			
					0.75 1 1.5 2
Random effects model me	ta-analv	sis resu	ılt		RR: 0.995, 95% CI: 0.976 to 1.014, p=0.59

Supplementary Figure 8. Forest plot for the paired meta-analysis of the included studies comparing STSF catheter with ST catheter for one-year post-ablation cardiac arrhythmia recurrence (STSF: SMARTTOUCH[®] SURROUNDFLOW; ST: THERMOCOOL SMARTTOUCH[®]; AF: Atrial fibrillation; RR: Rate ratio; CI: Confidence interval).

Study	ST	ſSF	S	Т	Rate Ratio
Study	Events	Total	Events	Total	Kate Katio
Unspecified AF					
Maurer 2018 [10]	15	74	9	35	
Zhou 2021 [13]	7	142	20	98	
Huang 2021 [17]	0	42	1	42	
Stabile 2020 (Subgroup 1)[12] 21	140	4	89	:
Stabile 2020 (Subgroup 2)[12] 14	149	9	74	
Random effects model		547		338	
Heterogeneity: $I^2 = 74\%$, $\tau^2 = 0$.7752, p ·	< 0.01			1 1 1 1
					0.1 0.5 1 2 10
Random effects model meta	a-analysis	s result			RR: 0.761, 95% CI: 0.301 to 1.925, p=0.564
Paroxysmal AF					
Dhillon 2019 [28]	11	50	18	50	
					0.5 1 2
					RR: 0.611, 95% CI: 0.322 to 1.158, p=0.131
Overall					
Random effects model		597		388	
Heterogeneity: $I^2 = 68\%$, $\tau^2 = 0$.	5323, p <				
<u> </u>	1				0.1 0.5 1 2 10
Random effects model meta	a-analysis	s result			RR: 0.727, 95% CI: 0.355 to 1.490, p=0.384

Supplementary Figure 9. Forest plot of the leave-one-out sensitivity analysis for pooled RR for one-year post-ablation cardiac arrhythmia recurrence between STSF catheter and ST catheter (RR: Rate ratio; CI: Confidence interval).



Pooled est	Pooled estimation after excluding one study									
Point estimation	95% CI	P-value	I ²							
0.714	[0.283; 1.803]	0.476	74%							
0.929	[0.501; 1.723]	0.815	50%							
0.755	[0.354; 1.609]	0.466	74%							
0.555	[0.342; 0.901]	0.017	30%							
0.718	[0.286; 1.803]	0.480	74%							
0.761	[0.301; 1.925]	0.564	74%							
0.727	[0.355; 1.490]	0.384	68%							

Supplementary Figure 10. Forest plot for the paired meta-analysis of the included studies comparing STSF catheter with ST catheter for the risk of overall complications related to RFCA (STSF: SMARTTOUCH[®] SURROUNDFLOW; ST: THERMOCOOL SMARTTOUCH[®]; AF: Atrial fibrillation; RR: Rate ratio; CI: Confidence interval).

Study	ST	ſSF	S	Т	
Study	Events	Total	Events	Total	Rate Ratio
Unspecified AF					L
Huang 2021 [17]	0	42	0	42	
Plenge 2020 [11]	1	60	1	20	
Halbfass 2017 [16]	2	50	0	50	
Lee 2019b [14]	0	39	0	32	
Random effects model		191		144	
Heterogeneity: $I^2 = 0\%$, $\tau^2 =$	= 0.1629, <i>p</i>	0 = 0.63			0.001 0.01 0.1 1 10 100 1000
Random effects mod	el meta-a	nalysis	result		RR: 1.113, 95% CI: 0.166 to 7.440, p=0.912
Paroxysmal AF					
Liu 2019 [26]	0	24	0	24	
Melby 2018 [23]	0	71	1	102	<u>=</u>
Dhillon 2019 [28]	0	50	3	50	_
Duytschaever 2019 [24]	3	86	9	243	- <u>+</u>
Random effects model		231		419	
Heterogeneity: $I^2 = 0\%$, τ^2	= 0, p = 0.	.71			
0	71				0.001 0.1 1 10 1000
Random effects mod	el meta-a	nalysis	result		RR: 0.673, 95% CI: 0.226 to 2.006, p=0.477
Overall					
Random effects model		422		563	
Heterogeneity: $I^2 = 0\%$, $\tau^2 =$	= 0, p = 0.	85			
					0.001 0.1 1 10 1000
Random effects mod	el meta-a	nalysis	result		RR: 0.766, 95% CI: 0.299 to 1.959, p=0.578

Supplementary Figure 11. Forest plot for the paired meta-analysis of the included studies comparing STSF catheter with ST catheter for foley catheter use (STSF: SMARTTOUCH[®] SURROUNDFLOW; ST: THERMOCOOL SMARTTOUCH[®]; RR: Rate ratio; CI: Confidence interval).

	STS	F	ST					
Study	Events	Total	Events	Total	Rate Ratio	RR	95%-CI	P-value
Melby 2018 [23]	31	71	86	102		0.518	[0.393; 0.684]	
Duytschaever 2019[24]	10	86	63	243		0.448	[0.241; 0.833]	
Random effects model Heterogeneity: $I^2 = 0\%$, $\tau^2 = 0\%$	= 0, p = 0.6	157 57		345		0.506	[0.393; 0.652]	<0.001
					0.5 1 2			

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Supplementary Figure 12. Forest plot for the paired meta-analysis of the included studies comparing STSF catheter with SF catheter for acute procedure success of PVI (STSF: SMARTTOUCH[®] SURROUNDFLOW; SF: SURROUNDFLOW; AF: Atrial fibrillation; RR: Rate ratio; CI: Confidence interval).

Events Total Events Total Unspecified AF Dugo 2016 [29] 26 26 26 26 26 26 26 26 26 26 26 26 26 26 26 26 26 26 26 26 26 26 26 26 26 26 26 26 26 26 26 26 26 27 1 0.9 1 RR: 1.000, 95% CI: 0.928 to 1.078, p=1.000 298 298 97 97 1 0.9 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	Events Total Events Total Total Interaction Unspecified AF Dugo 2016 [29] 26 26 26 26 0.9 1 RR: 1.000, 95% CI: 0.928 to 1.078, p=1.000 1 Paroxysmal AF Uetake 2020 [31] 298 298 97 97 1 RR: 1.000, 95% CI: 0.928 to 1.078, p=1.000 Overall Random effects model 324 123 1 Random effects model meta-analysis result RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000 0.9 1	Events Total Events Total Intervents Unspecified AF Dugo 2016 [29] 26 26 26 26 0.9 1 RR: 1.000, 95% CI: 0.928 to 1.078, p=1.000 RR: 1.000, 95% CI: 0.928 to 1.078, p=1.000 0.9 1 Paroxysmal AF 0.9 1 RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000 Overall Random effects model 324 123 0.9 1 Random effects model meta-analysis result RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000 0.9 1	Study	ST	SF	SF	7	Rate Ratio
Dugo 2016 [29] 26 26 26 26 $0.9 mtext{ 1}$ RR: 1.000, 95% CI: 0.928 to 1.078, p=1.000 Paroxysmal AF Uetake 2020 [31] 298 298 97 97 $0.99 mtext{ 1}$ RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000 Overall Random effects model 324 123 $0.99 mtext{ 1}$ Random effects model meta-analysis result Random effects model meta-analysis result RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000	Dugo 2016 [29] 26 26 26 26 $0.9 1$ RR: 1.000, 95% CI: 0.928 to 1.078, p=1.000 Paroxysmal AF Uetake 2020 [31] 298 298 97 97 $0.99 1$ RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000 Overall Random effects model 324 123 $0.99 1$ Random effects model meta-analysis result Random effects model meta-analysis result RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000	Dugo 2016 [29] 26 26 26 26 $0.9 1$ RR: 1.000, 95% CI: 0.928 to 1.078, p=1.000 Paroxysmal AF Uetake 2020 [31] 298 298 97 97 $0.9 1$ RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000 Overall Random effects model meta-analysis result Random effects model meta-analysis result RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000 0.9 1 RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000		Events	Total	Events	Total	Kate Katto
0.9 1 RR: 1.000, 95% CI: 0.928 to 1.078, p=1.000 Paroxysmal AF Uetake 2020 [31] 298 97 97 0.9 1 RR: 1.000, 95% CI: 0.928 to 1.078, p=1.000 Overall Random effects model 324 Heterogeneity: $I^2 = 0\%$, $\tau^2 = 0$, $p = 1.00$ Random effects model meta-analysis result RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000	0.9 1 RR: 1.000, 95% CI: 0.928 to 1.078, p=1.000 Paroxysmal AF Uetake 2020 [31] 298 97 97 0.9 1 RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000 Overall Random effects model 324 Heterogeneity: $I^2 = 0\%$, $\tau^2 = 0$, $p = 1.00$ Random effects model meta-analysis result RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000	0.9 1 RR: 1.000, 95% CI: 0.928 to 1.078, p=1.000 Paroxysmal AF Uetake 2020 [31] 298 97 97 0.9 1 0.9 1 RR: 1.000, 95% CI: 0.928 to 1.078, p=1.000 Overall Random effects model 324 123 0.9 1 0.9 1 Random effects model meta-analysis result 123 RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000	Unspecified AF					
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RR: 1.000, 95% CI: 0.928 to 1.078, p=1.000 Paroxysmal AF Uetake 2020 [31] 298 97 97 Image: Ima	RR: 1.000, 95% CI: 0.928 to 1.078, p=1.000 Paroxysmal AF Uetake 2020 [31] 298 97 97 Image: Ima	RR: 1.000, 95% CI: 0.928 to 1.078, p=1.000 Paroxysmal AF Uetake 2020 [31] 298 97 97 0.9 1 RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000 Overall Random effects model 324 123 0.9 1 RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000 Overall Random effects model 324 123 RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000 Overall Random effects model meta-analysis result RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000						
Paroxysmal AF Uetake 2020 [31] 298 298 97 97 0.9 1 RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000 Overall Random effects model 324 123 Heterogeneity: $I^2 = 0\%$, $\tau^2 = 0$, $p = 1.00$ 0.9 1 Random effects model meta-analysis result RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000	Paroxysmal AF Uetake 2020 [31] 298 298 97 97 0.9 1 RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000 Overall Random effects model 324 123 Heterogeneity: $I^2 = 0\%$, $\tau^2 = 0$, $p = 1.00$ 0.9 1 Random effects model meta-analysis result RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000	Paroxysmal AF Uetake 2020 [31] 298 298 97 97 0.9 1 RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000 Overall Random effects model 324 123 Heterogeneity: $I^2 = 0\%$, $\tau^2 = 0$, $p = 1.00$ 0.9 1 Random effects model meta-analysis result RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000						
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0.9 1 RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000 Overall Random effects model Heterogeneity: $I^2 = 0\%$, $\tau^2 = 0$, $p = 1.00$ Random effects model meta-analysis result RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000 Random effects model meta-analysis result RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000	0.9 1 RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000 Overall Random effects model Heterogeneity: $I^2 = 0\%$, $\tau^2 = 0$, $p = 1.00$ Random effects model meta-analysis result RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000 Random effects model meta-analysis result RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000	0.9 1 RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000 Overall Random effects model B24 Heterogeneity: $I^2 = 0\%$, $\tau^2 = 0$, $p = 1.00$ Random effects model meta-analysis result RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000 Random effects model meta-analysis result RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000	Uetake 2020 [31]	298	298	97	97	
RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000 Overall Random effects model 324 123 Heterogeneity: $I^2 = 0\%$, $\tau^2 = 0$, $p = 1.00$ 0.9 1 Random effects model meta-analysis result RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000	RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000 Overall Random effects model 324 123 Heterogeneity: $I^2 = 0\%$, $\tau^2 = 0$, $p = 1.00$ 0.9 1 Random effects model meta-analysis result RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000 Random effects model meta-analysis result	RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000 Overall Random effects model 324 123 Heterogeneity: $I^2 = 0\%$, $\tau^2 = 0$, $p = 1.00$ 0.9 1 Random effects model meta-analysis result RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000 Random effects model meta-analysis result						
Overall Random effects model324123Heterogeneity: $I^2 = 0\%$, $\tau^2 = 0$, $p = 1.00$ 0.91Random effects model meta-analysis resultRR: 1.000, 95% CI: 0.985 to 1.015, p=1.000	Overall Random effects model324123Heterogeneity: $I^2 = 0\%$, $\tau^2 = 0$, $p = 1.00$ 0.91Random effects model meta-analysis resultRR: 1.000, 95% CI: 0.985 to 1.015, p=1.000	Overall Random effects model324 324123Heterogeneity: $I^2 = 0\%$, $\tau^2 = 0$, $p = 1.00$ 0.9Random effects model meta-analysis resultRR: 1.000, 95% CI: 0.985 to 1.015, p=1.000						
Random effects model Heterogeneity: $I^2 = 0\%$, $\tau^2 = 0$, $p = 1.00$ 123Random effects model meta-analysis resultRR: 1.000, 95% CI: 0.985 to 1.015, p=1.000Random effects model meta-analysis resultRR: 1.000, 95% CI: 0.985 to 1.015, p=1.000	Random effects model Heterogeneity: $I^2 = 0\%$, $\tau^2 = 0$, $p = 1.00$ 123Random effects model meta-analysis resultRR: 1.000, 95% CI: 0.985 to 1.015, p=1.000Random effects model meta-analysis resultRR: 1.000, 95% CI: 0.985 to 1.015, p=1.000	Random effects model324123Heterogeneity: $I^2 = 0\%$, $\tau^2 = 0$, $p = 1.00$ 0.9Random effects model meta-analysis resultRR: 1.000, 95% CI: 0.985 to 1.015, p=1.000	0					RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000
Heterogeneity: $I^2 = 0\%$, $\tau^2 = 0$, $p = 1.00$ Random effects model meta-analysis result RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000	Heterogeneity: $I^2 = 0\%$, $\tau^2 = 0$, $p = 1.00$ Random effects model meta-analysis result RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000	Heterogeneity: $I^2 = 0\%$, $\tau^2 = 0$, $p = 1.00$ Random effects model meta-analysis result RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000			324		123	
Random effects model meta-analysis result RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000	Random effects model meta-analysis result RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000	Random effects model meta-analysis result RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000	Heterogeneity: $I^2 = 0\%$, τ^2	= 0, p = 1.0			125	
			Random effects model	meta-analy	sis resul	lt		RR: 1.000, 95% CI: 0.985 to 1.015, p=1.000

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Supplementary Figure 13. Forest plot for the paired meta-analysis of the included studies comparing STSF catheter with SF catheter for one-year post-ablation arrhythmia recurrence (STSF: SMARTTOUCH[®] SURROUNDFLOW; SF: SURROUNDFLOW; AF: Atrial fibrillation; RR: Rate ratio; CI: Confidence interval).

Study	ST	ſSF	S	F	Rate Ratio
Study	Events	Total	Events	Total	Kate Katio
Paroxysmal AF Uetake 2020 [31]	65	298	42	97	
					RR: 0.504, 95% CI: 0.368 to 0.689, p<0.00
Persistent AF					
Takamiya 2020 [32]	11	74	22	74	0.5 1 2 RR: 0.500, 95% CI: 0.262 to 0.956, p=0.03
Overall Random effects model	0 0	372		171	
Heterogeneity: $I^2 = 0\%$, $\tau^2 =$	= 0, p = 0.	98			0.5 1 2
Random effects model n	neta-analy	sis result			RR: 0.503, 95% CI: 0.379 to 0.667, p<0.0

Supplementary Figure 14. Forest plot for the paired meta-analysis of the included studies comparing STSF catheter with SF catheter for the risk of overall complications related to RFCA (STSF: SMARTTOUCH[®] SURROUNDFLOW; SF: SURROUNDFLOW; AF: Atrial fibrillation; RR: Rate ratio; CI: Confidence interval).

Study	ST	SF	S	F			Rate Ratio		
Study	Events	Total	Events	Total			Kale Kallo		
Unspecified AF									
Gonna 2017 [30]	0	100	2	100				-	
Dugo 2016 [29]	1	26	0	26					
Random effects model		126		126					
Heterogeneity: $I^2 = 32\%$, τ^2	= 1.1811,	p = 0.22				1	I	I	
					0.01	0.1	1	10	100
Random effects model me	ta-analysis	s result			RR:	0.745, 95%	% CI: 0.052 to 1	10.574, p=0	0.828
Persistent AF									
Takamiya 2020 [32]	4	74	2	74					
						I		I	I
					0.01	0.1	0.5 1 2	10	100
					RR:	2.000, 95%	% CI: 0.378 to 1	l0.587, p=0	.415
Overall									
Random effects model		200		200				~	
Heterogeneity: $I^2 = 0\%$, $\tau^2 <$	0.0001, p	= 0.37				I	1	I	
					0.01	0.1	1	10	100
Random effects model met	ta-analysis	s result			RR	: 1.381, 95	% CI: 0.367 to	5.193, p=0	.633

Supplementary Figure 15. Forest plot of the leave-one-out sensitivity analysis for pooled RR for the risk of overall complications related to RFCA between STSF catheter and SF catheter (RR: Rate ratio; CI: Confidence interval).

Excluded study		RR	
Omitting Gonna 2017 [30] Omitting Dugo 2016 [29] Omitting Takamiya 2020 [32]			_
Random effects model			_
	0.1	0.5 1 2	10

Point estimation	95% CI	P-value	I ²
2.185	[0.501; 9.537]	0.299	0%
0.906	[0.106; 7.730]	0.928	41%
0.745	[0.052; 10.574]	0.828	32%
1.381	[0.367; 5.193]	0.633	0%

Pooled estimation after excluding one study

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C	Supplementary Table 1. Second states for all databases of extended literature states 73	
	plementary Table 1. Search strategies for all databases of systematic literature retrieval. base retrieval via Ovid, run on July 31, 2022	
#	Searches	Results
1	exp atrial fibrillation/	100,822
2	atrial fibrillation.ti,ab,kw.	
3	1 or 2	175,990
4	(Smart Touch or Smarttouch or ST).af.	2,039,6
5	(Surround Flow or Surroundflow or SF).af.	147,154
6	4 and 5	9,825
7	STSF.af.	81
8	6 or 7 <u>B</u> R ³	9,875
9	3 and 8	336
10	limit 9 to yr="2016 -current" ≥	263
11	limit 10 to english language	260
Me	dline retrieval via Ovid, run on July 31, 2022	
#	Searches	Results
1	exp atrial fibrillation/	65,749
2	atrial fibrillation.ti,ab,kw.	83,864
3	1 or 2	96,391
4	(Smart Touch or Smarttouch or ST).af.	1,566,84
5	(Surround Flow or Surroundflow or SF).af.	58,697
6	4 and 5	4,937
7	STSF.af.	29
8	6 or 7	4,953
9	3 and 8	75
10	limit 9 to yr="2016 -current" bit limit 10 to english language graphic For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml bit	53
11	limit 10 to english language	53

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Tł	ne Cochrane library retrieval via Ovid, run on July 31, 2022	וד, וח	; ;	075	
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1	exp atrial fibrillation/	guid	5	on	5,190
2	atrial fibrillation.ti,ab,kw.	101	5	170	14,561
3	1 or 2	use		l t t	14,959
4	(Smart Touch or Smarttouch or ST).af.	- Sre	sei	October 2023. Do	66,732
5	(Surround Flow or Surroundflow or SF).af.	Pate	gne	202	26,824
6	4 and 5	a to	t men	÷ ⊽	2,022
7	STSF.af.	tex	t Su	N	9
8	6 or 7	i ar	perie	lloa	2,027
9	3 and 8	0	2 5	Ô.	38
10		ata	Ň	ro	21
11		min		from htt	20
W	eb of Science Core Collection, run on July 31, 2022	ng,	<u>.</u>		I
#	Searches	Altr	<u>}</u>	bmjo	Results
1	TS=atrial fibrillation	raini	5	oper	109,124
2	TS=(Smart Touch or Smarttouch or ST)	ng,	2	n.br	179,345
3	TS=(Surround Flow or Surroundflow or SF)	and	5	<u>1</u> .0	102,686
4	#2 AND #3	ISIM	2	ŝ	973
5	TS=STSF	nllar	2	Ŷ	56
6	#4 OR #5	Tech		June	1,018
7	#1 AND #6	nno	5	e 14	34
8	PY="2016-2022"	noiogie	2	, 202	21,184,249
9	#7 AND #8	es.	<u>,</u>	25 a	31
	ANFANG, run on July 31, 2022			nt Ag¢	
#	Searches			Jenc	Results
1	主题:("房颤" or "心房颤动" or "心房纤维颤动" or "心房纤颤")			e Bib	15,732
2	全部:("Smart Touch" or "Smarttouch" or "ST")			liogr	32,844
	For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml			liographique de l	

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2		20.101
3	全部:("Surround Flow" or "Surroundflow" or "SF")	28,101
4	2 AND 3	125
5	全部:("STSF")	3
6	4 OR 5	127
7	1 AND 6	3
CN	KI, run on July 31, 2022	
#	1 AND 6 Endotes KI, run on July 31, 2022 Endotes Searches Endotes	Results
1	TKA=('房颤' + '心房颤动' + '心房纤颤')	13,497
2	FT=('Smart Touch' + 'Smarttouch' + 'ST') 우듕 등	426,266
3	FT=('Surround Flow' + 'Surroundflow' + 'SF')	155,221
4	2 AND 3 55	18,007
5	FT=('STSF')	71
6	4 OR 5	18,070
7	1 AND 6	87
VIF	P, run on July 31, 2022	
#		Results
1	M=("房颤" or "心房颤动" or "心房纤维颤动" or "心房纤颤") OR R=("房颤" or "心房颤动" or "心房纤维颤动" or "心房纤颤") or "心房纤颤") or "心房纤颤")	13,437
2	U=("Smart Touch" or "Smarttouch" or "ST") OR R=("Smart Touch" or "Smarttouch" or "ST") Image: Constraint of the second secon	43,133
3		52,374
4	2 AND 3	288
5	U=("STSF") OR R=("STSF")	4
6	U=("STSF") OR R=("STSF") A 4 OR 5 C	291
7	1 AND 6 Bi Clinical Trials Registry, run on July 31, 2022 For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml	3
/	Clinical Trials Registry, run on July 31, 2022	

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4	1 (atrial fibrillation) AND (STSF or Smart Touch Surround Flow)	in	0755	7	_
5	EU Clinical Trials Registry, run on July 31, 2022	- Ľud	79	1	_
6 7	1 STSF or Smart Touch Surround Flow	ing	on 1	0	
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10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43	I STSF or Smart Touch Surround Flow International Clinical Trials Registry Platform, run on July 31, 2022 I STSF or Smart Touch Surround Flow	seignement Superieur (ABES) . s related to text and data mining, Al training, and similar technologies.	ber 2023. Downloaded from http://bmjopen.bmj.com/ on June 14, 2025 at Agence Bibliographique de I		
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Suppleme Reference ID	entary Ta Region	ble 2. Study Publication type	<u>characteris</u> Publication language	tics and main Study design	BMJ Open <u>n extracted informati</u> Patient inclusion and exclusion criteria	on from the inc Catheter comparison and sample size	cluded studies; Patient character@udir Patient character@udir	Main outcomes
Halbfass 2017 [16]	Germany	Full text	English	Prospective cohort study	Inclusion criteria: Patients with symptomatic, drug- refractory paroxysmal or persistent atrial fibrillation (AF) who underwent left atrial radiofrequency (RF) catheter ablation and post-procedural esophagogastroduodeno scopy (EGD) Exclusion criteria: Unspecified.	STSF (n=50) vs. ST (n=50)	Demographics 1 • Mean age: STSF vs. 6 (64.0±10.7 vs. 6 5 3mile.5 years, p=0.39); 5 6 • Male: STSF vs. 6 • Male: STSF vs. 6 • BMI: STSF vs. 6 • BMI: STSF vs. 6 • BMI: STSF vs. 6 • Paroxysmal Afast 6 • Clinical character 5 • Comorbidities • Hypertension: 5 • Stroke/transient ischemic attack: 5 • Stroke/transient ischemic attack: 5 • Stroke/transient ischemic attack: • TSF vs. ST (100 vs 6 • Mathematical character 5 • Comorbidities • Comorbidities • Stroke/transient ischemic attack: • STSF vs. ST (100 vs 6 • Stroke/transient ischemic attack: • Comorbidities • Comorbidities • Comorbidities • Stroke/transient ischemic attack: • STSF vs. ST (100 vs 6 • Stroke/transient ischemic attack: • Comorbidities • Comorbidities • Comorbidities • Comorbidities • Comorbidities	Procedural characteristics • Ablation time: STSF vs. ST (41.1±11.1 vs. 40.1±12.1 minutes, p=0.66); Clinical outcomes • Acute procedure success rat STSF vs. ST (100% vs. 100% • Any complications: STSF v ST (4% vs. 0%, p=0.49); • Cardiac tamponade: STSF v ST (2% vs. 0%); • Bleeding: STSF vs. ST (2% vs. 0%).
Horiuchi 2017 [18]	Japan	Abstract	English	Randomized controlled study	Inclusion criteria: Atrial fibrillation patients undergoing circumferential pulmonary vein isolation. Exclusion criteria: Unspecified.	STSF (n=20) vs. ST (n=20)	Pooled information of two groups Demographics O Solution • Mean age: 60± of yots; • Clinical characteristics • Paroxysmal AF: 47%%. Bibliographique graphique de	 Procedural characteristics Median radiofrequency time from superior to anterior sites STSF vs. ST (9 vs. 22 second p<0.01); Median radiofrequency time at inferior and posterior sites: STSF vs. ST (9 vs. 8 seconds p=NS); There was no difference between the two groups in the

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-								6/bmjopen-2023-075579 on 17 October Ensei cted by copyright, including for uses re Demographics	 mean contact force at each of 6 sites (anterior, anterosuperior, anteroinferior, inferior, posteroinferior, and posterosuperior site); Total number of residual conduction gaps: STSF vs. ST (1.0±1.1 vs. 0.9±1.1, <i>p</i>=NS).
	Ullah 2017 [19]	United Kingdom	Full text	English	Prospective cohort study	Inclusion criteria: Patients undergoing their first catheter ablation procedure for atrial fibrillation (AF) Exclusion criteria: Unspecified.	STSF (n=10) vs. ST (n=30)	• Mean age: STS# \$ \$7 (65.8±5.3 vs. 61 \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$	Procedural characteristics • Median catheter tip temperature at the start of energy delivery: STSF vs. ST (28 vs. 36 °C, $p < 0.005$); • Median impedance at start of energy delivery: STSF vs. ST (154 vs. 181 Ω , $p < 0.005$); • Median minimum catheter tip temperature during RF delivery: STSF vs. ST (25 vs. 35 °C, $p < 0.005$); • Median time to reach minimum catheter tip temperature: STSF vs. ST (8.4 vs. 1.2 seconds, $p < 0.005$); • Median maximum catheter tip temperature during RF delivery: STSF vs. ST (29 vs. 41 °C, $p < 0.005$); • Median time to reach maximum catheter tip temperature: STSF vs. ST (0 vs. 14.9 seconds, $p < 0.005$); • Median time to reach maximum catheter tip temperature: STSF vs. ST (0 vs. 14.9 seconds, $p < 0.005$); • Median time to reach maximum ablation power: STSF vs. ST (0.6 vs. 8.1
-	Chopra 2018 [25]	United States	Full text	English	Retrospectiv e study	Inclusion criteria: Patients aged between 18 and 81 years who had undergone a radiofrequency ablation procedure for the indication of paroxysmal AF at OhioHealth Riverside	STSF (n=24) vs. ST (n=23)	Pooled information of wo groups Clinical characteristics • Left atrial diameter 4.2±7.5 mm; • Left ventricular ejection fraction: 57.8%±7%; D: • CHADS VASc Score 2.4±1.4.	seconds, $p < 0.005$). Procedural characteristics • Procedure time: STSF vs. ST (192.7±46.6 vs. 213.9±43.5 minutes, $p=0.11$); • Ablation time: STSF vs. ST (43.8±13.8 vs. 49.1±14.8 minutes, $p=0.18$);
				For peer r	review only - ht	tp://bmjopen.bmj.com/	/site/about/guidel	ines.xhtml de	

Maurer Germany Full text English Prospective cohor study Inclusion criteria: Unspecified. STSF (n=75) vs. STG (12, 228, 82-727, 4sconds, p=0.39) (228, 82-729, 3vs. STG (12, 12-829, 3vs. STG (12, 12-836, 4vs. 1322,6489) (12, 12-74, 4sconds, p=0.39) (12, 127, 4sconds, p=0.39) (12, 12, 12, 12, 12, 12, 12, 12, 12, 12,				BMJ Open	6/bmjopen cted by co	Page 38 of
• Coronary arter disease: STSF (20.3% vs. 25.7%);	Germany	Full text	English	Columbus, Ohio, USA, from May 1, 2017, to June 1, 2018. Exclusion criteria: Unspecified. Inclusion criteria: Patients with symptomatic, drug- refractory paroxysmal, or short-term persistent AF (< 3 months in duration). Exclusion criteria: 1. Prior pulmonary vein isolation or left atrial surgery; 2. A left atrial (LA) diameter > 60 mm; 3. Severe valvular heart disease or contraindications to	bemographics die for the second state of the	523.6 \pm 277.4 seconds, p =0.39); • Total fluid: STSF vs. ST (2,288.8 \pm 725.8 vs. 3,105 \pm 803 mL, p <0.001); • Fluid via ablation catheter: STSF vs. ST (697.3 \pm 299.3 vs. 1277 \pm 315.8 mL, p <0.001); • Fluid from sources other than ablation catheter: STSF vs. ST (1591 \pm 583.6 vs. 1828 \pm 689 mL, p =0.21); • Post-RFA Furosemide use (0% vs. 39%; p =0.0006). Procedural characteristics • Procedure time: STSF vs. ST (131.3 \pm 33.7 vs. 133.0 \pm 42 minutes, p =0.995); • Ablation time: STSF vs. ST (1751 \pm 394.0 vs. 1604.6 \pm 287.8 seconds, p =0.201); • Fluoroscopy time: STSF vs. ST (14 \pm 6 vs. 13.5 \pm 6.6 minutes, p =0.559); • Total fluid: STSF vs. ST (265.5 \pm 64.4 vs. 539.6 \pm 118.2 mL, p <0.001); Clinical outcomes • Acute procedure success rate: STSF vs. ST (100% vs. 100%); • 12-month arrhythmia recurrence rate: STSF vs. ST (20.3% vs. 25.7%); • Audible steam pop: STSF vs.

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Melby 2018 [2:	Unspecifi 3] ed	Abstract	English	Retrospectiv e study	Inclusion criteria: Paroxysmal AF patients undergoing first-time ablation, guided by CARTO VISITAG™ Module. Exclusion criteria: Unspecified.	STSF (n=71) vs. ST (n=102)	Demographics • Mean age: STSE vs. ST (60 ± 10 vs. 61 ± 9 years, p 0.74; • Left ventricular ejection fraction: STSF vs. ST 60.2 ± 7.6 vs. $59.5\pm7.9\%$, p (50); • CHADS VASC Serve : STSF vs. ST (1.62 ± 1.4 vs. Structure 4, p=0.56); Comorbidities • Congestive heat the structure of the structur	Procedural characteristic • Procedure time: STSF (1.9 ± 0.5 vs. 1.9 ± 0.4 hou p=0.77); • Ablation time: STSF v. (37.4 ± 11.2 vs. 38.2 ± 12.3 ; minutes, $p=0.74$); • Fluoroscopy time: STS ST (3.1 ± 4.4 vs. 4.7 ± 2.7 minutes, $p<0.001$); • Fluoroscopy dose: STS ST (12.4 ± 16.7 vs. $27.3\pm$ mGy, $p<0.001$); • Total fluid: STSF vs. S (1505 ± 440 vs. 2353 ± 603 ; p<0.001); • Fluid via ablation cather STSF vs. ST (563 ± 168 v. 1145 ± 375 mL, $p<0.001$); • Foley catheter usage (9 STSF vs. ST (43.7% vs. 84.3%, $p<0.001$); Clinical outcomes • Any complications: ST ST (0% vs. 1%); • Cerebrovascular accide
Dhillon 2019 [2:	United 3] Kingdom	Full text	English	Prospective cohort study	Inclusion criteria: Consecutive patients with paroxysmal atrial fibrillation underwent pulmonary vein isolation guided by ablation index (AI) between January 2017 and October 2017. Exclusion criteria: Unspecified.	STSF (n=50) vs. ST (n=50)	and and Demographics Sintheta • Mean age: STSE vs. ST (60.1±11.8 vs. 549 ± 10.8 years, $p=0.915$); State • Male: STSF vs. $5T$ (00% vs. 48%, $p=0.042$); State • Median duration of SF : STSF vs. ST (24 vs. 42 morths, $p=0.057$); State • Left atrial diameter: STSF vs. ST (37.6±5 vs. 38.7±4mm, $p=0.145$); • CHA ₂ DS ₂ VASc Scere: STSF vs. ST (1.3±1.2 vs. 1) $p=0.184$);	 STSF vs. ST (0% vs. 1%) Procedural characteristic Mean procedure time: vs. ST (156 vs. 199 min <i>p</i><0.001); Mean ablation time: S' ST (27.2 vs. 43.2 minute <i>p</i><0.001); Mean left wide antral circumferential ablation STSF vs. ST (29.5 vs. 3 minutes, <i>p</i><0.001); Mean right wide antral circumferential ablation STSF vs. ST (32 vs. 38. minutes, <i>p</i>=0.001);

					BMJ Open		cted by copyright, inc Comorbidities	Page 4
			5	6			Comorbidities • Hypertension: GTSF5 s. ST (38% vs. 34%, p=0.83); • Diabetes Mellies: STSF vs. ST (12% vs. 6%, p=0.483); • Ischemic Hearth Disease: STSF vs. ST (4% vs. 225 Figure 2023. Downloaded to text and dent	 Mean fluoroscopy time: STSF vs. ST (7.7 vs. 8.5 minutes, p=0.079); Clinical outcomes Acute procedure success ra STSF vs. ST (68% vs. 48%, p=0.068); 12-month AF/AT recurrence rate: STSF vs. ST (6% vs. 34%); Any complications: STSF vs. ST (0% vs. 6%); Pericarditis: STSF vs. ST (0% vs. 4%); Femoral venous hematoma: STSF vs. ST (0% vs. 2%).
Duytschae ver 2019 [24]	Europe	Abstract	English	Prospective cohort study	Inclusion criteria: Patients underwent point-by-point paroxysmal atrial fibrillation ablations across 17 European centers in the VISTAX study. Exclusion criteria: Unspecified.	STSF (n=86) vs. ST (n=243)	Not reported Not reported Not reported Not reported	 Procedural characteristics Procedure time: STSF vs. S (137.4±30.1 vs. 162.9±36.9 minutes); Ablation time: STSF vs. S' (37.1±9.23 vs. 34.4±11.73 minutes); Fluid via ablation catheter: STSF vs. ST (785.3±356.0 v 1,255.6±469.3 mL); Foley catheter usage (%): STSF vs. ST (11.6% vs 25.9%); Clinical outcomes
Goldstein 2019a [20]	United States	Abstract	English	Retrospectiv e study	Inclusion criteria: Patients with a primary diagnosis of AF (≥18 years) who underwent radiofrequency ablation between 09/01/2016– 03/31/2018, identified from the Premier Healthcare database.	STSF (n=1,445) vs. ST (n=1,766)	Demographics o • Age group ≥70 $_{\infty}$ STS0 vs. ST (35.09% vs. 30.15%, $g=0.0031$); Clinical characteristics • Paroxysmal AF: ST $_{\infty}$ F vs. ST (63.32% vs. 67.21%, $e=0.0210$); • CHADS2VASc scorts 3: STSF vs. ST (43.39% vs. 35) vs. ST (43.39% vs. 35) vs. ST (43.39% vs. 45) p<0.001); o o o o o o o o	• Any complications: STSF ST (3.5% vs. 3.7%). Not reported

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			5	~ <u>~</u> ~	Exclusion criteria: Unspecified.		Comorbidities • Obesity: STSF \overrightarrow{s} s. \overbrace{S}^{c} (23.88% vs. 19.42%, p=0 \overleftarrow{t} 022 \overleftarrow{t} • Diabetes: STSF \overrightarrow{vs} s. \overbrace{S}^{T} (20.90% vs. 17.27%, p=0 \overleftarrow{t} 090 \overleftarrow{t} • Atrial flutter: \overbrace{S}^{O} SF \overleftarrow{vs} . ST (41.38% vs. 32.6%, \overbrace{S}^{c} <0.0001); • Valvular disease: \overleftarrow{s}^{C} \overleftarrow{s}^{c} ST (21.87% vs. 12.34%, \overbrace{S}^{c} <0.0001); • Cardiomyopath \overleftarrow{s}^{C} \overleftarrow{s}^{c} ST (12.87% vs. 9.68%, \overleftarrow{s}^{c}).0042); • Hypertension: \overleftarrow{s}^{C} \overleftarrow{s}^{c} ST (69.48% vs. 63.03%, \overleftarrow{s}^{c}).0042); • Heart failure: \overbrace{S}^{C} \overleftarrow{s}^{c} ST (20.69% vs. 17.8 \overleftarrow{s}^{c} \overleftarrow{s}^{c} =0.0407).	
Goldstei 2019b [21]	States	Abstract	English	Retrospectiv e study	Inclusion criteria: Patients with a primary diagnosis of AF (≥18 years) who underwent index (first occurrence) radiofrequency ablation in an outpatient setting (09/01/2016– 03/31/2018), identified from the Premier Healthcare database. Exclusion criteria: Unspecified.	STSF (n=571) vs. ST (n=571)	Not reported rieur (ABES) . nd data mining, Al training, and si	Hospital readmission outcomes • 4-6 months all-cause readmission rate: STSF vs. ST (2.78% vs. 2.78%, <i>p</i> =1.000); • 4-6 months cardiovascular- related inpatient readmission rate: STSF vs. ST (1.23% vs. 1.23%, <i>p</i> =1.000); • 4-6 months AF-related inpatient readmission rate: STSF vs. ST (0.93% vs. 0.62%, <i>p</i> =0.6535).
Lee 2019 [15]	∂a South Korea	Abstract	English	Prospective cohort study	Inclusion criteria: Drug refractory symptomatic AF patients. Exclusion criteria: Unspecified.	STSF (n=66) vs. ST (n=32)	Pooled information of wo groups Demographics • Mean age: 61±& yeas; Clinical characteristics • Paroxysmal Algorithm • Satisfies at Agence	 Procedural characteristics Procedure time: STSF vs. ST (160±37 vs. 199±42 minutes, p<0.001); Ablation time: STSF vs. ST (44±10 vs. 66±14 minutes, p<0.001); Clinical outcomes Acute procedure success rate STSF vs. ST (96.3% vs. 95.8%, p=0.613).
Lee 2019 [14]	9b South Korea	Abstract	English	Retrospectiv e study	Inclusion criteria: Drug refractory symptomatic AF patients.	STSF (n=39) vs. ST (n=32)	Pooled information of two groups Demographics bi Mean age: 61±10 years;	Procedural characteristics

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					Exclusion criteria: Unspecified.		Cted by copyright, inclusion Male: 79%; t, inclusion Clinical character Paroxysmal AF:	 Procedure time: STSF v (168±34 vs. 199±42 min p=0.001); Ablation time: STSF vs (47±11 vs. 66±14 minute p<0.001);
Liu 2019 [26]	China	Full text	Chinese	Retrospectiv e study	Inclusion criteria: Drug- refractory paroxysmal	STSF (n=24) vs. ST (n=24)	J for uses related to textup Demographics • Mean age: STS	Clinical outcomes • Acute procedure succes STSF vs. ST (96.0% vs. 95.8%, p=0.867); • Any complications: ST ST (0% vs. 0%). Procedural characteristic • Procedure time: STSF v
				Ne.	AF patients underwent pulmonary vein isolation. Exclusion criteria: Unspecified		(65.0±9.6 vs. 65 ± ± a. e.	 (67 vs. 70 minutes, <i>p</i>=0.4 Ablation time: STSF vs. (35.3±6.4 vs. 39.6±9.0 minutes, <i>p</i>=0.07); Fluoroscopy time: STS ST (7.8±3.1 vs. 11.2±6.3 minutes, <i>p</i>=0.02); Total infusion fluid: ST
					Chippenned.		• Duration of AFast ST SF vs. ST (10.4 \pm 10.1 vs. 6 \pm 4.2 months, p=0.08); • Left atrial diameter: TSF vs. ST (34.1 \pm 13.9 vs. 39.9 \pm 5.4 mm, p=0.09); • Left ventricular jection	 Total infusion fund. ST ST (356 vs. 700 mL, p<0 Clinical outcomes Acute procedure succes STSF vs. ST (100% vs. 1 p=1); Any complications: ST
							fraction: STSF va ST 55 ± 6 vs. $53\pm 8\%$, $p=0.23$) for the second sec	ST (0% vs. 0%).
							 Heart failure: STSF \$\$. ST (25.0% vs. 41.7%, p=0.22); Hypertension: STSF \$\$. ST (41.7% vs. 50%, p=0.56); Diabetes: STSF vs. \$\$T (12.5% vs. 29.2%, p=0.16); Stroke: STSF vs. ST\$4.2% vs. 	

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$ \begin{array}{r} 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ 12 \\ 13 \\ 14 \\ 15 \\ 16 \\ 17 \\ 18 \\ 19 \\ 20 \\ 21 \\ 22 \\ 23 \\ 24 \\ 25 \\ 26 \\ 27 \\ 28 \\ 29 \\ 30 \\ 31 \\ 32 \\ 33 \\ 34 \\ 35 \\ 36 \\ 37 \\ 38 \\ 39 \\ 40 \\ 41 \\ 42 \\ \end{array} $	Solimene 2019 [12]	Italy	Full text	English	Prospective cohort study	Inclusion criteria: Patients with paroxysmal or persistent AF who underwent their first AF ablation. Exclusion criteria: 1. Age <18; 2. Longstanding persistent AF (AF was the sole rhythm for the last 12 months); 3. AF secondary to a transient or correctable abnormality, including electrolyte imbalance, trauma, recent surgery, infection, toxic ingestion, and endocrinopathy; 4. Intra-atrial thrombus, tumor, or other abnormality precluding catheter insertion; 5. Left ventricular ejection fraction <35%; 6. Women of childbearing potential who are or might be pregnant; 7. Hematological contraindications to ionizing radiation exposure; 8. Presence of complex congenital heart disease; 9. Cardiac surgery within 1 month from enrollment.	STSF (Subgroup with AI 330-450, n=162; Subgroup with AI 380-500, n=151) vs. ST (Subgroup with AI 330-450, n=96; Subgroup with AI 380- 500, n=81)	The subgroup with A 130-450 Demographics no • Mean age: STS F vs. S T (60±12 vs. 58±10 years) • Male: STSF vs. ST (68% vs. 71%); • BMI: STSF vs. ST (67.5±4.3 vs. 27.2±3.8 kg/m ²) s Fibo • Paroxysmal Alform S • Paroxysmal Alform S • Left ventricular D • Comorbidities d • Hypertension: S • ST (5.3% vs. ST (30.4% vs. 31.3%) D • Ischemic heart H • STSF vs. ST (1.2% vs. 1%); • Valvulopathy: STSF vs. ST (1.2% vs. 1%); • Dilated cardior yop ahy: STSF vs. ST (4.9% vs. H .2%; • Previous transfit is hemic attack/Stroke: S • SF vs. ST (4.3% vs. 1%); • Diabetes mellits: S • ST (1.9% vs. 0%; • Mean age: STSF vs. ST (1.1% vs. 2.1%) • Male: STSF vs. ST (5.2±4 vs. ST (1.9% vs. 0%; • Male: STSF vs. ST (5.2±4 vs. ST (5.2±4 vs. ST (5.2±5 vs. ST (5.2±4 vs. ST (5.2±4 vs. ST (5.2±5 vs. ST (5.2±5 vs. ST	The subgroup with AI 330-450 Procedural characteristics • Procedure time: STSF vs. ST (120 ± 72 vs. 129 ± 44 minutes); • Ablation time: STSF vs. ST (33.3 ± 11.5 vs. 30.7 ± 10 minutes); • Fluoroscopy time: STSF vs. ST (257 ± 356 vs. 542 ± 285 seconds); • Total fluid: STSF vs. ST (701 ± 287 vs. 1105 ± 573 mL); Clinical outcomes • Acute procedure success rate: STSF vs. ST (94.5% vs. 97.5%); The subgroup with AI 380-500 Procedural characteristics • Procedure time: STSF vs. ST (125 ± 73 vs. 144 ± 44 minutes); • Ablation time: STSF vs. ST (13 ± 11.7 vs. 28.8 ± 13.7 minutes); • Fluoroscopy time: STSF vs. ST (379 ± 454 vs. 540 ± 416 seconds); • Total fluid: STSF vs. ST (836 ± 503 vs. $1,732\pm664$ mL); Clinical outcomes • Acute procedure success rate: STSF vs. ST (92.2% vs. 94.5%).
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lenge Germany Full text 020 [11]	rmany Full text English Prospective cohort study Inclusion criteria: Consecutive patients with symptomatic paroxysmal or persistent AF scheduled for pulmonary vein isolation. Exclusion criteria: Age younger than 18 years, reversible causes of AF, prior pulmonary vein isolation, and intracardiac thrombus.	STSF (n=60) vs. STSF (n=20) STSF (n=20)	Procedural characteristics • Procedure time: STSF v (106.3 \pm 28.4 vs. 116.7 \pm 20 minutes, $p=0.2$); • Ablation time: STSF vs (25.9 \pm 7.3 vs. 32.1 \pm 16 mi p=0.045); • RF time for PVI left vei STSF vs. ST (836.5 \pm 296 1,086.6 \pm 523.0 seconds, p=0.08); • RF time for PVI right v STSF vs. ST (913.5 \pm 1,43 vs. 1,002.8 \pm 544.6 second p=0.8); • Fluoroscopy time: STSI ST (16.0 \pm 6.7 vs. 13.8 \pm 5. minutes, $p=0.25$) • Fluoroscopy dose: STSI ST (1,854.7 \pm 1,247.9 vs. 1,756.7 \pm 822.6 µGym2, p=0.77); • Fluid via ablation cathe STSF vs. ST (241.4 \pm 79.6 540.3 \pm 229.5 mL, $p<$ 0.01

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1 2 3 4			• Cardiovascular disease: STSF vs. ST (20% vs. 10%) 55 • Cardiomyopatha: ST&F vs. ST	Clinical outcomes • Any complications: STSF vs.
5 6 7 8 9 10 11 12			(15% vs. 13.3%, ==0.22); • Diabetes mellites: SISF vs. ST (15% vs. 13.3%, ==0.22); • Renal failure: SISF vs. ST (11.7% vs. 0%, , ==0.22); • Sleep-disordered in thing: STSF vs. ST (8, ==0.22);	 Any completations: STSF vs. ST (1.7% vs. 5%); Audible steam pop: STSF vs. ST (1.7% vs. 0%); Bleeding: STSF vs. ST (0% vs. 5%).
12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41	Stabile Italy Full text English Prospective 2020 [22]		Duplicate with Soo text and data mining, Al training, and similar technologies.	The subgroup with AI 330-450 Clinical outcomes • 12-month arrhythmia recurrence rate: STSF vs. ST (14.9% vs. 4.5%); The subgroup with AI 380-500 Clinical outcomes • 12-month arrhythmia recurrence rate: STSF vs. ST (9.4% vs. 12.2%).
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Zhang China	Full text	Chinese	Retrospectiv	ionizing radiation exposure; 8. Presence of complex congenital heart disease; 9. Cardiac surgery within 1 month from enrollment. Inclusion criteria:	STSF (n=34) vs.	6/bmjopen-2023-075579 on 17 October Enseit Demographics	Procedural characteristics
2020 [27]			e study	 I. Recurrent paroxysmal atrial fibrillation (defined as paroxysmal atrial fibrillation that can be terminated by itself or intervention within 7 days after the attack), which does not respond to antiarthythmic drugs. 2. Preoperative echocardiography showed left atrial diameter <55mm and left ventricular ejection fraction (LVEF) > 35%. Exclusion criteria: Stroke, heart valve disease, heart failure (cardiac function IV level), atrial thrombus, cardiomyopathy (including hypertrophic cardiomyopathy, acute coronary syndrome, hyperthyroidism, coronary heart disease, chronic renal insufficiency (chronic kidney disease stage 4- 5) 	ST (n=34)	bendgraphics $\mathbf{r}_{\mathbf{g}} = \mathbf{r}_{\mathbf{g}} \mathbf{r}_{\mathbf{g}} \mathbf{r}_{\mathbf{g}}$ • Mean age: STSF vs. $\mathbf{g}_{\mathbf{g}} \mathbf{r}_{\mathbf{g}} \mathbf$	• Right PVI time: STSF vs

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Huang	China	Full text	Chinese	Retrospectiv	Inclusion criteria:	STSF (n=42) vs.	cted by copyright Demographics	Procedural characterist
2021 [17	1			e study	 Aged between 18 and 75 years; ECG examination confirmed AF attack. Exclusion criteria: Patients with cardiac thrombosis; 	ST (n=42)	• Mean age: STSE vs \mathcal{S} T (62.3±8.8 vs. 61 \mathbf{D} ±10 \mathbf{D} years, p=0.510); S • Male: STSF vs ST (49.0% vs. 64.3%, p =0.643) C Clinical characters S • Paroxysmal AF	 Ablation time: STSF v (28.3±5.1 vs. 51.3±6.7 minutes, p<0.001); Clinical outcomes Circumferential pulmivein isolation success r STSF vs. ST (100.0% v
					 Patients complicated with active hemorrhagic disease, severe organic disease, or advanced chronic wasting disease; Left atrial diameter > 		(45.2% vs. 54.8% F 2 383); • Left atrial diameter: STSF vs. ST (4.38 \pm 0.48 vs. 441 \pm 0.62 cm, p=0.854); • Left ventricular effection fraction: STSF value of the state of the	 100.0%, p=1.000); Complement ablation CPVI: STSF vs. ST (45 85.7%, p=0.087); 12-month arrhythmia recurrence rate: STSF v
					55mm;4. Patients with valvular heart disease or vascular disease requiring		(59.45 \pm 4.72 vs. 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273 , 273	(0% vs. 2.4%, <i>p</i> =0.314) • Any complications: S' ST (0% vs. 0%).
					surgical treatment.		• Hypertension: $p = 0.827$; (54.8% vs. 52.4% $p = 0.827$); • Coronary heart disease: STSF vs. ST (21.4% vs. 21.3%, p=1.000);	
							 Cardiac insuffizience: STSF vs. ST (9.5% vs. 9.12%, p=1.000); Diabetes: STSFavs. ST (4.8% vs. 11.9%, p=0.226); Cerebral infarct from TSF vs. ST (7.1% vs. 19.2%, p=0.106). 	
Zhou 2021 [13	China]	Full text	Chinese	Retrospectiv e study	Inclusion criteria: Patients undergoing first-time percutaneous radiofrequency catheter ablation.	STSF (n=142) vs. ST (n=98)	Demographics a • Mean age: STS # vs.6T (63.2 \pm 9.2 vs. 63 \pm 10 \pm years, p=0.950); 4 • Male: STSF vs.6T (59.2% vs.	Procedural characteristi • Procedure time: STSF (96.4 \pm 31.6 vs. 119.5 \pm 3 minutes, p=0.021); • Ablation time: STSF v (28.6.15.2 vs. (15.15))
					Exclusion criteria: Unspecified.		65.3%, <i>p</i> =0.491 Clinical characteristics • Paroxysmal AF: STOF vs. ST (59.9% vs. 66.3%, <i>p</i> =3335); • Left atrial diameter: TSF vs.	(38.6±15.2 vs. 61.5±13 minutes, <i>p</i> =0.013); • Fluoroscopy time: ST ST (15.3±3.3 vs. 16.9± minutes, <i>p</i> =0.144);
							ST (43.4±4.4 vs. 44.4 b) mm, p=0.193);	Clinical outcomes • 12-month arrhythmia recurrence rate: STSF v (4.9% vs. 20.4%, p=0.0

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							• Left ventricular ejecton	
							raction: STSF vg S1261.4 \pm 5.7 vs. 61.2 \pm 5.1%, p=0.8 \textcircled{b}); • CHA ₂ DS ₂ VAS Score: STSF vs. ST (2.3 \pm 1.7 \textcircled{s} . 1.9 \pm 1.7, p=0.243).	
Dugo 2016 [29]	Germany	Abstract	English	Retrospectiv e study	Inclusion criteria: Patients with AF underwent ablation between July 2014 and May 2015, with a minimum follow-up of 6 months. Exclusion criteria: Unspecified.	STSF (n=26) vs. SF (n=26)	Demographics • Mean age: STS • Sector • Male: STSF vs • Male: STSF vs • Male: STSF vs • Clinical character • Paroxysmal AF • Paroxysmal AF • Clinical character • Paroxysmal AF • Clinical character • Paroxysmal AF • Clinical character • Paroxysmal AF • SF (96% vs. 81%); • Left atrial diameter • SF (40±7 vs. 42 • Al training, a • Al training, a	 Procedural characterist Procedure time: STSI (98±32 vs. 78±31 minu 0.05); Fluoroscopy time: ST SF (11±7 vs. 7±3 minu 0.05); Clinical outcomes Acute procedure succ STSF vs. SF (100% vs Any complications: S SF (0% vs. 0%); Cardiac tamponade: S SF (0% vs. 0%); Stroke: STSF vs. SF (vs. 0%); Atrial-esophageal fist STSF vs. SF (0% vs. 0 Vascular access: STS
Gonna 2017 [30]	United Kingdom	Full text	English	Prospective cohort study	Inclusion criteria: Atrial fibrillation patients undergoing ablation, Between May and December 2015. Exclusion criteria: Unspecified.	STSF (n=100) vs. SF (n=100)	Demographics d • Mean age: STS 2 . vs 3 F (60.5 ± 14.0 vs. 614 ± 16.3 years, p=0.38); • Male: STSF vs 6 SF 4 3% vs. 71%, $p=0.75$). 14 15 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17 17	 (3.8% vs. 0%); Procedural characteristics Mean procedure time vs. SF (225.5 vs. 221.4 minutes, p=0.55); Mean fluoroscopy time STSF vs. SF (25.8 vs. minutes, p=0.03); Clinical outcomes Any complications: SSF (0% vs. 2%, p=0.16); Pericardial effusion: vs. SF (0% vs. 1%, p=1); Attrioventricular bloc vs. SF (0% vs. 1%, p=1);
	Japan	Full text	English	Retrospectiv e study	Inclusion criteria: Patients who underwent	STSF (n=74) vs. SF (n=74)	Demographics	Procedural characteris

Page 49 of 55						BMJ Open		6/bmjopen-2023 cted by copyrigh	
1 2								n-2023 opyrigl	
3 4 5 6						first catheter ablation for drug-refractory persistent AF. Exclusion criteria:		 Mean age: STSF. vs. SF (63±10 vs. 63±12 years, =0.62); Male: STSF vs. SF (26% vs. 80%, p=0.69); BMI: STSF vs. F (25±4 vs. 96); 	 Procedure time: STSF vs. SF (180 vs. 200 minutes, p=0.150); Fluoroscopy time: STSF vs. SF (67 vs. 76 minutes, procedure)
7 8 9						Unspecified.		• Median duration of persistent	p=0.026; Clinical outcomes
10 11 12 13 14 15 16 17								 Median duration of tersistent AF: STSF vs. SFatth Svs. 6 months, p=0.30) for the system of the system of	 12-month arrhythmia recurrence rate: STSF vs. SF (15% vs. 30%); Any complications: STSF vs. SF (5% vs. 3%, p=1.0); Pericardial effusion: STSF vs. SF (1.4% vs. 1.4%); Esophageal gastroparesis: STSF vs. SF (1.4% vs. 0%);
17 18 19 20 21 22 23						er revi		Comorbidities • Heart failure: STSE S. SF (18% vs. 20%, $p=0.83$) • Hypertension: STSE S. SF (61% vs. 54%, $p=0.5$) • Diabetes melliture: STSE vs. SF (20% vs. 19%, $p=1.00$).	 Phrenic nerve injury: STSF vs. SF (1.4% vs. 0%); Aspiration pneumonia: STSF vs. SF (1.4% vs. 0%); Sinus node injury as a result of superior vena cava isolation: STSF vs. SF (0% vs. 1.4%).
24 25 26 27 28 29	Uetake 2020 [31]	Japan	Full text	English	Prospective cohort study	Inclusion criteria: Paroxysmal AF patients who underwent their first radiofrequency catheter ablation procedure.	STSF (n=298) vs. SF (n=97)	Demographics p_{1} be a second structure of the sec	Procedural characteristics • Ablation time: STSF vs. SF (2,056.8±534.5 vs. 2,401.1±733.4 seconds, p<0.001);
30 31 32 33 34						Exclusion criteria: 1. Severe valvular disease; 2. Left ventricular ejection fraction < 35%; 3. Left atrial		• BMI: STSF vs. $F (24.1\pm3.5 \text{ vs.} 24.0\pm3.1 \text{ kg/m}^2, =0.435);$ Clinical characteristic • Duration of AFOST F vs. SF (32.1 \pm 3.5 vs. 2 9 9 \pm 4 52 months, p =0.023); • Left atrial diameter: TSF vs.	Clinical outcomes • Acute procedure success rate: STSF vs. SF (100% vs. 100%); • 12-month arrhythmia recurrence rate: STSF vs. SF (21.8% vs. 43.3%, <i>p</i> <0.001).
35 36 37 38 39 40						dimension > 55 mm; 4. Active thyroid disease; 5. Hypertrophic cardiomyopathy; 6. Hemodialysis;		SF (41.0±6.0 vs. 40.05.9 mm, p=0.709); • Left ventricular ejection fraction: STSF vs. SF (5.8±7.7 vs. 65.5±8.4%, p=0.82);	
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				7. Use of antiarrhythmic drugs during the blanking period.		• CHA ₂ DS ₂ VASC Scale: STSF vs. SF (1.94 \pm 1.28 vs. 551 \pm 1.13, p=0.010); • Hypertension: SF vs. SF (53.4% vs. 52.6% p=0.493); • Congestive heat failure: STSF vs. SF (4.7% vs. 2.8% p=0.203); • Diabetes mellits SS SSF vs. SF	
		Ko,	r 0-			(10.1% vs. 13.4% B =\$230); • Previous stroke paransient ischemic attack: CF3 [9] vs. SF (3.4% vs. 1.0%, E = 2 [2]); • Vascular disease: F SF vs. SF (5.7% vs. 1.0%, E = 4 [2]).	
Ikeda 2021 [33]	Japan Full t	text English	Retrospectiv e study	Inclusion criteria: 1. Age of > 20 years and provision of informed consent to undergo a second AF ablation at our institute, the performance of the second AF ablation using high-density mapping or the conventional method (CARTO [®] mapping system; Biosense Webster, Irvine, CA, USA) during that period; 2. \geq 3 months of follow- up at the outpatient clinic in our institute. Exclusion criteria: 1. Refusal to participate in the study; 2. An inability to undergo follow-up for any reason; 3. The lack of use of a 3D mapping system.	STSF (n=51) vs. CELSIUS® (n=49)	Demographics a f d • Mean age: STS f f ELSIUS [®] (63.5±8.54 vs. 6420007 years, p=0.98); f	Procedural characteristic • Procedure time: STSF CELSIUS® (260.5±82.7 255.8±45.3 minutes, $p=0$ • Fluoroscopy dose: STS CELSIUS® (313.2±187.9 363.4±257.3 mGy, $p=0.2$ Clinical outcomes • 12-month arrhythmia recurrence rate: STSF vs CELSIUS® (33% vs. 169 p=0.017); • Cardiac tamponade: ST CELSIUS® (0% vs. 0%) • Cerebral infarction: ST CELSIUS® (0% vs. 0%) • Bleeding: STSF vs. CELSIUS® (13.7% vs. 1 • Congestive heart failure STSF vs. CELSIUS® (2 0%, $p=0.32$); • Pericarditis: STSF vs. CELSIUS® (2% vs. 0%, $p=0.32$).

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							• Diabetes mellitus: STSF vs. CELSIUS® (2% \overrightarrow{R} s. 8 \overleftarrow{S} , $p=0.15$); • Chronic kidney lise \overrightarrow{R} : STSF vs. CELSIUS® (\overleftarrow{S} vg 16%, p=0.19).	
Reinsch 2021 [36]	Germany	Full text	English	Retrospectiv e study	Inclusion criteria: Atrial fibrillation patients undergoing ablation at the Alfried Krupp Krankenhaus, Essen, Germany from October 2014 to June 2019. Exclusion criteria: Unspecified.	STSF (n=690) vs. Thermocool NAVISTAR® (n=99)	Demographics O • Mean age: STSE ys O Thermocool NA SISIO R [®] (67.5+10.6 vs. 63(SP) years):	Procedural characteristics • Procedure time: STSF vs. Thermocool NAVISTAR [®] (160±48 vs. 190±47 minutes); • Ablation time: STSF vs. Thermocool NAVISTAR [®] (43±19 vs. 58±27 minutes); • Fluoroscopy time: STSF vs. Thermocool NAVISTAR [®] (5±3 vs. 7±4 minutes); Clinical outcomes • Cardiac tamponade: STSF vs. Thermocool NAVISTAR [®] (1.7% vs. 2.9%).
Di 2020 [35]	Italy	Abstract	English	Prospective cohort study	Inclusion criteria: Patients with paroxysmal or persistent AF underwent point-by- point pulmonary vein isolation. Exclusion criteria: Unspecified.	CARTO+STSF (n=59) vs. Rhythmia System TM + DirectSense (n=57)	Pooled information of two groups Clinical characteristics • Paroxysmal Alg 63% es at Agence Bibliog	Procedural characteristics • Procedure time: CARTO+STSF vs. Rhythmia System TM + DirectSense (180 \pm 56 vs. 180 \pm 89 minutes, p=0.590); • Fluoroscopy time: CARTO+STSF vs. Rhythmia System TM + DirectSense (13 \pm 9 vs. 20 \pm 12 minutes, p=0.002); Clinical outcomes

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	CARTO+STSF	
Juckel Germany Abstract English Prospective Inclusion criteria: STSF (n=69) vs. Not re 2022 [34] Cohort study Patients undergoing DiamondTemp radiofrequency ablation for AF. Exclusion criteria: Unspecified.	• Procedure time DiamondTemp ^{TT} vs. 98.8 ± 30.1 mi p=0.002); • Ablation time:	rectSense %); /thmia Vs. Rhythmia rectSense(14%); itions: Vs. Rhythmia rectSense (0% rectSense (0% rectSense (0% rectSense (0% racteristics te: STSF vs. TM (78.2 \pm 25.6 ninutes, : STSF vs. TM (78.2 \pm 25.6 ninutes, : STSF vs. TM (5.5 \pm 2.5 utes, p<0.006); lose: STSF vs. TM (5.5 \pm 2.5 utes, p<0.006); lose: STSF vs. TM (5.5 \pm 2.5 utes, p<0.006); lose: STSF vs. TM (5.5); hes ure success rate ondTemp TM %);

PRISMA 2020 Checklist

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1 2	PRISM	MA 20	BMJ Open 66 bm jopen 97 copyrigh 2023	
3 4 5	Section and Topic	ltem #	Checklist item	Location where item is reported
6	TITLE	1		
7	Title	1	Identify the report as a systematic review.	Line 1 to 3
8 9	ABSTRACT		See the PRISMA 2020 for Abstracts checklist.	
10	Abstract	2	See the PRISMA 2020 for Abstracts checklist.	See abstract
11	INTRODUCTION	1		
12	Rationale	3	Describe the rationale for the review in the context of existing knowledge.	Line 59 to 62
13	Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	Line 63 to 69
14	METHODS	1		
15	Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	Line 78 to 85
16 17	Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted identify studies. Specify the date when each source was last searched or consulted.	Line 89 to 99
18 19	Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used	Supplementary Table 1
20 21 22	Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation bools as in the process.	Line 101 to 108, and Figure 1
23 24 25	Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each dependently, any processes for obtaining or confirming data from study investigators, and if applicable, detage of automation tools used in the process.	Line 110 to 116, and Figure 1
26 27	Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which esuits to collect.	Line 121 to 125
28 29 30		10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, and g sources). Describe any assumptions made about any missing or unclear information.	Line 118 to 120
31 32	Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	Line 128 to 133
33 34	Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	Line 135 to 141
35 36	Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	Line 143 to 147
37 38		13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	Not applicable
39 40		13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	Supplementary Table 2
41 42 43		13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	Line 147 to 150, and Line 156 to 158
44 45 46		13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analy s, meta-regression).	Line 151 to



PRISMA 2020 Checklist

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PRIS	MA 2(BMJ Open 66 bm jopen-2023 D20 Checklist	
Section and Topic	ltem #	Checklist item	Location where item is reported
		n n	154
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	Line 154 to 155
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting).	Line 155 to 156
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	Line 147 to 150
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to t	Line 161 to 166, and Figure 1
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they we concluded.	
Study characteristics	17	Cite each included study and present its characteristics.	Line 168 to 171, and Supplementary Table 2
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	Line 180 to 182, and Supplementary Table 2
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) and effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	Line 292 to 294, Line 297 to 299, Line 302 to 303, and Line 311 to 323
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	Line 184 to 189
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direct of the effect.	Line 192 to 194, Line 214 to 215, Line 238 to 240, Line 257 to 260, Line 276 to 279, Line 288 to 290, Line 300 to 301, and Line 304 to 306
	20c	Present results of all investigations of possible causes of heterogeneity among study results. For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml	Line 195 to 205, Line 217

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PRISM	MA 20	BMJ Open 66 bm jopen-2023 D20 Checklist	
Section and Topic	ltem #	Checklist item	Location where item i reported
0		Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	to 230, Line 241 to 249, Line 260 to 268, and Line 280 to 283
2 2 3 4 5	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	Line 206 to 208, Line 23 ⁻ to 232, Line 250 to 251, Line 268 to 270, and Line 283 to 286
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis a set as a set of a	Line 208 to 211, and Line 232 to 233
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	Figure 2, 3, 4 and 5, and Table 1
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	Line 325 to 333
	23b	Discuss any limitations of the evidence included in the review.	Line 388 to 408
	23c	Discuss any limitations of the review processes used.	Line 398 to 400
	23d	Discuss implications of the results for practice, policy, and future research.	Line 367 to 370, and Line 406 to 408
OTHER INFORMA			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the register was not registered.	Not applicab
protocor	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	Not applicab
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	Not applicab
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the view.	Line 445
Competing interests	26	Declare any competing interests of review authors.	Line 441 to 443
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	Upon reques
_		For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml	

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