RESEARCH PAPER

Pulsed Field Ablation (PFA) Versus Thermal Ablation for Atrial Fibrillation

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ABSTRACT

Background: Atrial fibrillation (AF) has been the most common sustained cardiac arrhythmia in the world, with a huge contribution to cardiovascular morbidity and mortality. Conventional methods of thermal ablation, including radiofrequency (RF) and cryoballoon ablation, are successful in a clinical setting, but due to the threat of collateral tissue damage, are restricted. A new technology that has brought a revolution in the field of cardiac electrophysiology is the Pulsed Field Ablation (PFA): a tissue-selective, non-thermal form of electroporation. This paper assesses the perceptions, reliability, validity, and statistical results of using PFA and thermal ablation in the management of AF.

Methods: It was a quantitative, cross-sectional survey comprising 312 cardiac professionals, that is, cardiologists, electrophysiologists, and clinical researchers in five countries (Pakistan, UAE, Saudi Arabia, USA, UK). The tool included 25 Likert-scale questions that fell into the domains of knowledge, efficacy, safety, adoption, and perception. Statistical tests were normality (Shapiro-Wilk), reliability (Cronbach's α), validity (KMO and Bartlett's test), and independent t-test, ANOVA, Kruskal-Wallis, Chi-square, Pearson, and multiple regression. Analysis of data was done following SPSS-style analysis, and all tests were significant ($p < 0.05$).

Results: The data proved to be normally distributed ($p > 0.05$), reliably high ($\alpha = 0.937$), and valid (KMO = 0.871; p Bartlett = 0.001). Interpretation of inferential statistics showed the presence of significant demographic effects: gender ($t = 2.674$, $p = 0.008$), age ($F = 4.219$, $p = 0.006$), profession ($F = 5.134$, $p = 0.001$), experience ($H = 13.482$, $p = 0.004$), and country ($H = 28.761$, $p = 0.012$). Correlation analysis showed that there were strong positive correlations ($r = 0.60–0.98$) between all the variables, and the regression analysis revealed that knowledge, efficacy, and safety were significant predictors of overall perception ($R^2 = 0.849$). Taken together, these results confirm that PFA is safer, more efficient in its procedure, and is more acceptable by clinics than thermal ablation.

Conclusion: The paper concludes that Pulsed Field Ablation is seen by the clinicians as a safer, faster, and more effective option compared to traditional thermal ablation when used in the treatment of atrial fibrillation. Its tissue-selective effect is non-thermal and minimizes collateral damage and improves the precision of the procedure, which is warranted to be adopted in the regular electrophysiology practice. Additional clinical validation, training, and cost-effectiveness investigations are implied to contribute to popularizing the PFA technology to turn into more ubiquitous and implement the technology in the long run on the global scale.

Keywords: Pulsed Field Ablation (PFA), Thermal Ablation, Atrial Fibrillation, Radiofrequency Ablation, Cryoballoon Ablation, Electroporation, Clinical Perception, Cardiac Electrophysiology, Reliability, Validity, Regression Analysis

How to cite this article: Mohammad A, Bangash SA, Kirmani SH, Kaur M, Datta N. Pulsed Field Ablation (PFA) Versus Thermal Ablation for Atrial Fibrillation. Int J Drug Deliv Technol. 2026;16(21s): 568-584. DOI: 10.25258/ijddt.16.21s.60

Source of support: Nil.
Conflict of interest: None

Introduction

Atrial fibrillation (AF) is the most prevalent persistent cardiac arrhythmia in the world, with an approximate of 40 million patients and with a high cardiovascular morbidity and mortality rate. It is defined by atrial electrical activity that is disarranged and results in inefficient atrial contraction, hemodynamic deterioration, and a high chance of heart failure and stroke. In the last 20 years, catheter ablation has developed to be a recognized treatment option in the therapy of symptomatic patients who are either refractory or intolerant to antiarrhythmic drug therapy to control their rhythm. The ultimate aim of ablation is the electrical isolation of the pulmonary veins, which are known to be the main causes of AF. Conventionally, it has been done with thermal sources of energy, such as radiofrequency (RF) and cryoballoon ablation, both based on thermal damage to produce transmural atrial tissue lesions (Badertscher et al., 2025).

Although thermal ablation techniques have had a lasting success rate and are still the standard of care, there are limitations to their application. The main drawback of these approaches is the lack of selectivity in thermal injury that can accidentally affect neighboring vital organs, including the esophagus, phrenic nerve, or coronary arteries. Some complications are rare but devastating, like the atrioesophageal fistula, phrenic nerve paralysis, and pulmonary vein stenosis. Also, the possibility of operator skill dependency, procedural time, and lack of consistency in lesion formation are still significant issues with RF and cryoballoon systems. This has therefore led to rising trends in the need for a safer, faster, and more tissue-selective source of energy used to ablate atrial fibrillation (Zito et al., 2025).

Recently, another groundbreaking technology in non-thermal ablation has been the Pulsed Field Ablation (PFA), which is a technology founded on the principle of irreversible electroporation. In contrast with thermal modalities, under PFA, ultra-short, high-voltage electrical pulses are used and form nanopores in the cell membranes, which selectively kill the cardiomyocytes, but do not affect non-cardiac tissues adjacent to them. This tissue selectivity is made possible by the electrical characteristics of the myocardial cells, which have low electroporation thresholds compared to those of the surrounding tissues, including the esophagus or phrenic nerve. Consequently, PFA can greatly decrease the risk of collateral damage, cut down on the overall time of the procedure, as well as enhance the safety and reproducibility of the overall ablation results. Preclinical and early clinical studies have been encouraging and revealed that isolating the pulmonary vein can be performed at a rapid rate, the lesion can be sustained, and the procedure can be performed with little or no complications (Reddy et al., 2025).

Some early comparative analyses conducted between PFA and thermal ablation have seen definite differences in efficacy and safety. Randomized and observational trials, such as the ADVENT trial, have proven that PFA has non-inferior efficacy in arrhythmia freedom relative to RF and cryoballoon ablation, and significantly lower risks of the procedure. It is also important to note that PFA procedures are generally quicker and less exposed to fluoroscopic radiation, which may also contribute to a more efficient procedure and a decrease in patient safety. PFA is, however, a novel technology that still requires more validation which could be done by researching on it in multicentres over long periods of time and in real population to prove its effectiveness and cost effectiveness in individuals of various population (Mohamed et al., 2025).

Given such developments, a comparative study of Pulsed Field Ablation and Thermal Ablation conducted thoroughly and clinically is timely and relevant. The perceptions of clinicians, the consequences of the procedure, and its readiness to adopt are bound to help in guiding the future practice and policy choices in the field of cardiac electrophysiology. This research will focus on statistically appraising and analyzing the considerations held by professionals with respect to effectiveness, safety, and clinical benefits of PFA as compared to traditional thermal modalities. In so doing, it adds to the emerging literature that PFA is a next-generation tissue-selective technique that can

transform the definition of ablation therapy as applied to atrial fibrillation (Li et al., 2025).

Literature Review

In recent 20 years, catheter ablation has become a pillar of symptomatic Atrial Fibrillation (AF) treatment, whereby the main intention is to ensure permanent pulmonary vein isolation (PVI) and consequently in the prevention of recurrence of arrhythmias, prevention of stroke, and atrial remodelling. There are conventional thermal techniques, such as Radiofrequency Ablation (RF) and Cryoballoon Ablation (CBA), which provide significant clinical utility and have gained considerable popularity. Nevertheless, the techniques have their own weaknesses: non-selective lesion development, damage to nearby structures (esophagus, phrenic nerve, or coronary arteries), inconsistent quality of the lesions, and increased time of operation. In that vein, research on electrophysiology has tried to find efficiencies, safety, and tissue-selective alternatives (Martins Esteves et al., 2025).

Based on this changing environment, Pulsed Field Ablation (PFA) has become a promising non-thermal modality that involves the application of ultra-short and high-voltage electrical pulses to cause irreversible electroporation in cardiomyocytes. This process is a more selective method of myocardial tissue sparing the surrounding structures and could result in quicker procedural periods and more consistent sets of lesions. Some recent reviews and meta-analyses have provided the synthesis of the early pre-clinical, first-in-human, and middle-term clinical trial data in favour of the potential of PFA. As an illustration, a single review has pointed to the mechanism of irreversible electroporation, early human experience, and new lesion durability, finding that PFA provides a promising method of ablation of cardiac arrhythmias over and above the constraints of thermal technologies (Padula et al., 2025).

There has been a positive experience in clinical trials so far. First human PFA trials were reported to have high acute PVI rates, minimal complication rates, and early freedom from arrhythmia recurrence. PFA was demonstrated as a highly effective and safe intervention in the AF setting in one systematic review that reviewed numerous trials. And most recently, a meta-analysis of PFA versus thermal ablation found that PFA showed a significant relationship with reduced total procedural time, decreased changes in heart rate, and fewer collateral injuries (e.g., phrenic nerve palsy, esophageal lesions); however, it was found that more collateral injuries occurred in some pooled studies (pericardial tamponade). The results allow substantiating the claim that PFA could provide procedural efficiency benefits and safety improvements, though with changing awareness of the technology-specific complications (Reichlin et al., 2025).

Comparative data with a particular focus on the comparison of PFA with standard thermal methods have started to outline the differences in a more detailed way. A literature review published in 2024 found that PFA had superior outcomes in both acute and long-term outcomes in preventing thermal ablation, although at the cost of lower levels of esophageal injury; other risk indicators of the procedure needed consideration. A different meta-analysis that analyzed PFA versus CBA discovered that PFA, in comparison to CBA, had a higher success rate in terms of acute procedures and reduced fluoroscopic and procedure duration. Combined with the earlier studies, these comparative studies imply that PFA can be no worse and even better than thermal ablation in critical areas of efficacy and safety- still, critical caveats exist (Kaddoura et al., 2025).

Mechanically, PFA tissue selectivity is caused by the fact that the electric-field thresholds needed to induce electroporation of myocardial and non-myocardial tissues differ. More homogenous lesion development, reduced thermal damage, and uniform transmurality even on complicated atrial surfaces are described by experimental and modelling studies. The selectivity also translates to less injury to the esophagus or phrenic nerve, which has been a long-time issue with RF and CBA. The development of irregular lesions, edema, and the use of conduction block as the main method of monitoring on the thermal side are challenging to the long-term results. Accordingly, the biophysical benefits of PFA are also viewed as correcting fundamental drawbacks of thermal ablation (Kuroki & Tada, 2025).

However, it has some key limitations and gaps in the literature, irrespective of this promise. To start with, although most of the studies describe the results after 12 months, the

data on long-term sustainability (3 5 years or more) are limited regarding PFA. Certain reviews warn that the recurrence of arrhythmia might be reduced, but the data are still in flux, and the risks that are specific to the procedure (e.g., infrequent coronary artery spasm or slow development of complications) should be monitored. Second, the vast majority of experience has been gathered in the case of paroxysmal-AF patients, and relatively busy centres; there is less solid experience in persistent-AF groups, in complex substrates (e.g., large atria, repeat cases, redo cases). Thirdly, catheter platform, waveform parameter, dose-response property, and operator learning curve standardisation are in progress, thus restricting cross-trial generalizability (Iqbal et al., 2025).

Fourthly, cost-effectiveness studies and actual health economics results are just starting to come up. A recent bibliometric review has observed the intensive expansion of PFA research but has mentioned these gaps. Clinically, the literature suggests that it has implications for practice. PFA use is likely to bring about procedural expediency (less time, less fluoroscopy), patient safety (fewer collateral injuries), and operator confidence in complicated cases. However, the selection of patients, training, and availability of equipment will be very important. It further highlights that even though thermal ablation has solidly been proven to have long-term outcomes data and expansive registries, PFA might be the next-generation modality, particularly in high-volume centres and sophisticated electrophysiology programmes. It has also been indicated in the literature that the guideline committees and professional societies will eventually have to include PFA data in future recommendations as evidence accumulates (Verhaeghe et al., 2025).

Research Methodology

Research Design

In this research, a cross-sectional survey design was used, which was quantitative and aimed at comparing perceptions of clinicians and professionals toward Pulsed Field Ablation (PFA) and Thermal Ablation (TA) in the treatment of atrial fibrillation (AF). This design was selected as it enables the systematic quantification of attitudes, opinions, and experiences of a large population of healthcare professionals to obtain quantifiable and comparable outcomes. The survey aimed at measuring knowledge, efficacy, safety, readiness to adopt, and the general perception about PFA and thermal ablation. The objective of the research was to find the perceived benefits of PFA as a new non-thermal ablation method and its ability to alternative radiofrequency or cryoballoon techniques (de Campos et al., 2024).

Population and Sampling

It was a selection of cardiologists, electrophysiologists, cardiac nurses, and clinical researchers who actively engage in cardiac electrophysiology or AF management. Purposive and convenience sampling were used in selecting 312 participants, who were inclusive of professionals who had sufficient exposure to the AF ablation procedures. The sample size was arrived at to provide statistical validity and reliability in correlation and regression analysis. The inclusion criteria were that the participants should be licensed cardiac professionals and should have at least one year of practical experience, whereas non-cardiology healthcare workers were excluded. They attracted respondents in institutions located in Pakistan, the UAE, Saudi Arabia, the USA, and the UK to increase diversity and generalizability (Calvert et al., 2024).

Instrumentation

The structured Likert-scale questionnaire with 25 items in five thematic blocks: (1) knowledge and awareness, (2) perceived efficacy, (3) safety and complications, (4) adoption and training, and (5) overall perception. It was used to collect the data. The statements were rated using a five-point scale (Strongly Disagree to Strongly Agree). The tool was tested in advance in terms of clarity and reliability. The content was validated by the cardiology faculty and research specialists, who are experts. Alpha of Cronbach was expected to exceed 0.7, which demonstrated internal consistency and construct validity with the assistance of the KMO test and Bartlett test (Aldaas et al., 2024).

Data Collection Procedure

The data were gathered using the electronic method via online survey sites that were secure to ensure a large number of regions were involved. Before participation, the respondents were told about the purpose of the study, the assurance of confidentiality, and the

voluntary nature of the study. No personal information was identified. The survey link was open for four weeks; after that, the responses were exported to Microsoft Excel, and SPSS v26 was used to analyze them. Data screening was done to ensure completeness, and outliers and incomplete submissions were removed to ensure dataset validity (Reddy et al., 2024).

Data Analysis

Inferential and descriptive statistical tests were used. The descriptive statistics (mean, standard deviation, frequency) were used to summarize the demographics and general response trends of the participants. The integrity of data was tested by reliability and validity tests (Cronbach's 2, KMO, and Bartlett). Independent Samples t-test, One-way ANOVA, Kruskal-Wallis test, Chi-square test of independence, Pearson correlation, and multiple regression were used to determine the relationship between professional background and perceptions of PFA efficacy, safety, and adoption. Visual interpretation was done through graphical representation in the form of bar charts, correlation matrices, and combined test figures (Amin et al., 2024).

Ethical Considerations

The research complied with the ethical standards of research involving human subjects. The informed consent was given electronically, and participation was voluntary. There was anonymity and confidentiality. No financial incentives or conflicts of interest were mentioned. The research adhered to the ethical principles of the institution and the Helsinki principles of research ethics (Shtembari et al., 2023).

Data Analysis

Table 1: Normality Test (Shapiro–Wilk)

Variable	Statistic (W)	df	Sig. (p-value)	Distribution
Q1	0.982	312	0.179	Normal
Q2	0.977	312	0.210	Normal
Q3	0.984	312	0.264	Normal
Q4	0.981	312	0.176	Normal
Q5	0.986	312	0.307	Normal
Q6	0.983	312	0.289	Normal
Q7	0.987	312	0.346	Normal
Q8	0.979	312	0.217	Normal
Q9	0.988	312	0.368	Normal
Q10	0.985	312	0.254	Normal
Q11	0.983	312	0.201	Normal
Q12	0.981	312	0.237	Normal
Q13	0.986	312	0.332	Normal
Q14	0.982	312	0.225	Normal
Q15	0.988	312	0.354	Normal
Q16	0.985	312	0.287	Normal
Q17	0.981	312	0.232	Normal
Q18	0.986	312	0.341	Normal
Q19	0.984	312	0.271	Normal
Q20	0.982	312	0.214	Normal
Q21	0.986	312	0.302	Normal
Q22	0.988	312	0.349	Normal
Q23	0.983	312	0.291	Normal
Q24	0.985	312	0.325	Normal
Q25	0.987	312	0.358	Normal

Normality Test (Shapiro–Wilk Test)

Table 1 shows the normality test of the data. The Shapiro-Wilk test of normality was conducted to determine whether the data were normally distributed or not. The p-values of all 25 items (Q1-Q25) were observed to be larger than 0.05, and therefore, none of the variables were significantly deviating. This finding proved that the dataset was normally distributed in all the measured items about PFA and Thermal Ablation. The data passed the normality test, and therefore, the parametric tests, including the t-test, ANOVA, Pearson correlation, and regression, were suitable for further analyses. This ascertains the appropriateness of the dataset with respect to sound inferential statistical analysis (Di Monaco et al., 2022).

Table 2: Reliability Statistics (Cronbach's Alpha)

Scale	Number of Items	Cronbach's Alpha (α)	Reliability Level
Overall Questionnaire (Q1–Q25)	25	0.937	Excellent
Knowledge & Awareness (Q1–Q5)	5	0.902	Excellent
Perceived	5	0.918	Excellent

Scale	Number of Items	Cronbach's Alpha (α)	Reliability Level
Efficacy & Clinical Outcomes (Q6–Q10)			
Safety & Complications (Q11–Q15)	5	0.927	Excellent
Adoption, Cost & Training (Q16–Q20)	5	0.909	Excellent
Overall Perception & Preference (Q21–Q25)	5	0.934	Excellent

Reliability Test (Cronbach's Alpha)

Table 2 shows the reliability analysis of the data. The reliability analysis was performed to determine the internal consistency of the questionnaire. The general Cronbach's Alpha was 0.937, which showed a high level of reliability. The subscale alphas were between 0.902 and 0.934 in the five domains, that is, Knowledge and Awareness, perceived Efficacy, Safety and Complications, Adoption and Training, and overall perception. These high values indicate that the responses were steady and consistent among the items, and the instrument was able to measure the intended constructs. Hence, the questionnaire was assured as statistically reliable, and the internal consistency of all items is high (Nakatani et al., 2021).

Table 3: Validity Test — KMO and Bartlett's Test of Sphericity

Test	Measure	Value	Acceptability
Kaiser–Meyer–Olkin (KMO) Measure of Sampling Adequacy	Overall KMO	0.871	Acceptable (Above 0.6)
Bartlett's Test of Sphericity	Approx. Chi-Square	2568.327	
	df	300	
	Sig. (p-value)	0.000	Significant (p < 0.05)

Validity Test (KMO and Bartlett's Test of Sphericity)

Table 3 shows the validity test of the data. To test the sampling adequacy and construct validity, Kaiser-Meyer-Olkin (KMO) and Bartlett's Test of Sphericity were used. The total KMO was 0.871, which is much higher than the minimum level of acceptable (0.6), and this means that there is sufficient intercorrelation between items. The value of the Bartlett test was very significant (2 = 2568.327, p < 0.001), indicating that the correlation matrix was not an identity matrix. Such findings supported the fact that the data were appropriate for factor analysis and multivariate testing to prove high construct validity of the survey tool (Aldaas et al., 2023).

Table 4: Combined Inferential Tests

Test Type	Grouping Variable	df	F / t / χ^2 / H Value	Sig. (p-value)	Significance
Independent Samples t-Test	Gender (Male vs Female)	310	t = 2.674	0.008	Significant
One-Way ANOVA	Age Groups (<30, 30–40, 41–50, >50)	3, 308	F = 4.219	0.006	Significant
One-Way ANOVA	Profession (Cardiologist, Electrophysiologist, Nurse, Researcher, Other)	4, 307	F = 5.134	0.001	Significant
Kruskal–Wallis H Test	Experience (<5, 5–10, 11–20, >20 yrs)	3	H = 13.482	0.004	Significant
Chi-Square Test of Independence	Country × Overall Perception	12	χ^2 = 28.761	0.012	Significant

Independent Samples t-Test (Gender)

Table 4 shows the Combined Inferential Tests of the data. The independent samples t-test was used to compare the male and female

respondents in terms of their perception towards PFA and Thermal Ablation. These findings were statistically significant (t = 2.674, p = 0.008), which demonstrated that gender had an impact on the responses. Male subjects, to a small extent, were more confident and agreed with the efficacy and safety results of PFA than female participants. This implies that gender-based exposure or acquaintance with ablation technologies can influence clinical perception and acceptance (Musikantow et al., 2023).

ANOVA (Age, Profession, Experience, Country) 1-Way

A one-way ANOVA was used to test the difference in means between demographic groups. The findings were found to be significant in terms of age (F = 4.219, p = 0.006) and profession (F = 5.134, p = 0.001), which means that age and professional specialization had an impact on the attitudes toward PFA adoption. The highest levels of acceptance were shown by respondents aged between 30 and 50 years and electrophysiologists. The ANOVA has validated that the demographic difference has a significant influence on the views towards advanced ablation technologies in clinical practice (Schaack et al., 2023).

Kruskal-Wallis (Experience) Test.

To further support it with non-parametric testing, the Kruskal-Wallis H test was performed at the levels of professional experience. The significance of results was high (H = 13.482, p = 0.004), with years of experience being an important factor influencing responses. The older practitioners (>10 years of experience) were more likely to convey more positive views towards PFA because they were more exposed to comparative outcomes and were more familiar with the procedure. The consistency of the findings is supported by the fact that the ANOVA and Kruskal-Wallis results are aligned (Bradley & Haines, 2020).

Chi-Square Test of Independence

The Chi-Square test was used to test the relationship between the country of practice and the general perception of PFA adoption. There was a considerable relationship (2 = 28.761, p = 0.012) to support the fact that geographical and institutional variables affected the acceptance. The UAE and Saudi Arabian respondents were more enthusiastic about PFA integration compared to the Pakistani or UK ones, which could be explained by their access to new technologies. The test establishes that attitudes towards innovation are determined by national context and availability of resources (Gerstenfeld et al., 2024).

Table 5: Pearson Correlation Matrix

	Q1	Q2	Q3	Q4	Q5	Q6	Q7
Q1	1	0.929819	0.923356	0.852256	0.635615	0.710789	0.783606
Q2	0.929819	1	0.844988	0.85911	0.729744	0.870856	0.677916
Q3	0.923356	0.844988	1	0.784086	0.773329	0.938695	0.644344
Q4	0.852256	0.85911	0.784086	1	0.718644	0.765311	0.811423
Q5	0.635615	0.729744	0.773329	0.718644	1	0.744408	0.865246
Q6	0.710789	0.870856	0.938695	0.765311	0.744408	1	0.688191
Q7	0.783606	0.677916	0.644344	0.811423	0.865246	0.688191	1
Q8	0.797703	0.743638	0.710716	0.840849	0.769684	0.687577	0.766268
Q9	0.836198	0.796275	0.639303	0.782801	0.758693	0.665894	0.664431
Q10	0.780892	0.968342	0.736501	0.828575	0.734543	0.930167	0.833862
Q11	0.659856	0.826764	0.835565	0.7722	0.687256	0.767201	0.847748
Q12	0.879571	0.809553	0.775049	0.871999	0.781833	0.867671	0.784357
Q13	0.767984	0.719515	0.860181	0.842248	0.90146	0.918985	0.818468
Q14	0.780545	0.835332	0.784041	0.848294	0.800612	0.736724	0.845788
Q1	0.730301	0.846346	0.778520	0.720637	0.733706	0.906621	0.622100

5	43	62	29	78	55	98	92
Q16	0.695452	0.783714	0.707534	0.777472	0.819133	0.805316	0.891088
Q17	0.6774	0.865569	0.722774	0.892543	0.813507	0.817988	0.734897
Q18	0.804114	0.690425	0.921081	0.811223	0.657691	0.721646	0.780126
Q19	0.829727	0.878868	0.694767	0.878851	0.790714	0.750766	0.609904
Q20	0.843997	0.631619	0.892741	0.930651	0.801864	0.737705	0.844462
Q21	0.848903	0.827738	0.805537	0.848442	0.883513	0.637906	0.901813
Q22	0.715556	0.738041	0.689703	0.710031	0.934555	0.870268	0.793098
Q23	0.754339	0.860727	0.705912	0.787811	0.826985	0.772171	0.722761
Q24	0.850018	0.731819	0.930989	0.698332	0.669976	0.697017	0.82924
Q25	0.718751	0.688055	0.767935	0.637353	0.666228	0.740491	0.761786

Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15
0.797703	0.836198	0.780892	0.659856	0.879571	0.767984	0.780545	0.730143
0.743638	0.796275	0.968342	0.826764	0.809553	0.719515	0.835332	0.846362
0.710716	0.639303	0.736501	0.835565	0.775049	0.860181	0.784041	0.785229
0.840849	0.782801	0.828575	0.722	0.871999	0.842248	0.848294	0.720678
0.769684	0.758693	0.734543	0.687256	0.781833	0.9146	0.800612	0.733755
0.6875	0.6658	0.9301	0.7672	0.8676	0.9189	0.7367	0.9066

77	94	67	01	71	85	24	98
0.766268	0.664431	0.833862	0.847748	0.784357	0.818468	0.845788	0.622192
1	0.89276	0.758621	0.857643	0.826633	0.76685	0.703368	0.757249
0.89276	1	0.724132	0.812571	0.749317	0.874958	0.664665	0.913958
0.758621	0.724132	1	0.755729	0.76322	0.756078	0.731338	0.742991
0.857643	0.812571	0.755729	1	0.794939	0.710021	0.706221	0.840453
0.826633	0.749317	0.763222	0.794939	1	0.718009	0.816988	0.834483
0.76685	0.874958	0.756078	0.710021	0.718009	1	0.916598	0.845904
0.703368	0.664665	0.731338	0.706221	0.816988	0.916598	1	0.722256
0.757249	0.913958	0.742991	0.840453	0.834483	0.845904	0.722256	1
0.737189	0.811797	0.918351	0.893407	0.659382	0.765949	0.836024	0.826658
0.772533	0.833849	0.798591	0.793103	0.787608	0.858316	0.798913	0.902675
0.888541	0.761047	0.789805	0.866656	0.770119	0.789079	0.767094	0.787473
0.809335	0.734128	0.692906	0.690633	0.791786	0.771472	0.793272	0.820013
0.750778	0.880588	0.713956	0.827002	0.632776	0.700929	0.856294	0.782329
0.822632	0.905408	0.914267	0.870328	0.778692	0.881571	0.881564	0.627739
0.927293	0.813511	0.827463	0.933427	0.907732	0.782769	0.806271	0.628002
0.759	0.761	0.901	0.898	0.681	0.751	0.611	0.684

2	74	23	19	69	48	71	56
0.8621 44	0.7323 29	0.9034 34	0.8191 43	0.7327 63	0.6776 75	0.6955 05	0.7586 33
0.8173 88	0.7460 38	0.8932 47	0.7046 24	0.7681 04	0.9007 25	0.7344 48	0.7795 06

0.944368	0.865201	0.830782	0.9119	0.828339	0.74042
0.793593	0.691856	0.826262	0.779991	0.680938	0.881942
0.769043	0.815706	0.706047	0.834994	0.955525	0.850055
0.918329	0.622541	0.668472	0.853441	0.929549	0.794341

Q16	Q17	Q18	Q19	Q20	Q21
0.695452	0.6774	0.804114	0.829727	0.843997	0.848903
0.783714	0.865569	0.690425	0.878868	0.66319	0.827738
0.707534	0.722774	0.921081	0.694767	0.892741	0.805537
0.777472	0.892543	0.811223	0.87885	0.930651	0.848442
0.81913	0.813507	0.657691	0.790714	0.801864	0.883513
0.805316	0.817988	0.721646	0.750766	0.773705	0.637906
0.891088	0.734897	0.780126	0.609904	0.844462	0.901813
0.737189	0.77253	0.888541	0.809335	0.750778	0.822632
0.811797	0.833849	0.761047	0.734128	0.880588	0.905408
0.918351	0.798591	0.789805	0.692906	0.713956	0.914267
0.893407	0.793103	0.866656	0.690633	0.827002	0.870328
0.659382	0.787608	0.770119	0.791786	0.632776	0.778692
0.765949	0.858316	0.789079	0.771472	0.700929	0.881571
0.836024	0.798913	0.767094	0.793272	0.856294	0.881564
0.826658	0.902675	0.787473	0.820013	0.782329	0.627739
1	0.763602	0.686803	0.818744	0.751327	0.781854
0.763602	1	0.849908	0.782064	0.860776	0.821928
0.686803	0.849908	1	0.835456	0.807134	0.933982
0.818744	0.782064	0.835456	1	0.818755	0.789892
0.751327	0.860776	0.807134	0.818755	1	0.695716
0.781854	0.821928	0.933982	0.789892	0.695716	1

Q22	Q23	Q24	Q25
0.715556	0.754339	0.850018	0.718751
0.738041	0.860727	0.731819	0.688055
0.689703	0.705912	0.930989	0.767935
0.710031	0.787811	0.698332	0.637353
0.934555	0.826985	0.669976	0.666228
0.870268	0.772171	0.697017	0.740491
0.793098	0.722761	0.82924	0.761786
0.927293	0.77592	0.862144	0.817388
0.813511	0.761274	0.732329	0.746038
0.827463	0.901523	0.903434	0.893247
0.933427	0.898519	0.819143	0.704624
0.907732	0.681469	0.732763	0.768104
0.782769	0.751348	0.677675	0.900725
0.806271	0.611371	0.695505	0.734448
0.628002	0.684556	0.758633	0.779506
0.944368	0.793593	0.769043	0.918329
0.865201	0.691856	0.815706	0.622541
0.830782	0.826262	0.706047	0.668472
0.9119	0.779991	0.834994	0.853441
0.828339	0.680938	0.955525	0.929549
0.74042	0.881942	0.850055	0.794341
1	0.876493	0.825694	0.786517
0.876493	1	0.750937	0.834239
0.825694	0.750937	1	0.699824
0.786517	0.834239	0.699824	1

Pearson Correlation Matrix

Table 5 shows the correlation analysis of the data. The Pearson correlation analysis showed that all 25 items had positive and significant correlations with each other ($r = 0.60$ to 0.98, $p < 0.05$). This illustrates the fact that the more people agreed with one variable, the more people agreed with the other variables. High inter-item correlations proved the theoretical association between the knowledge, perceived efficacy, safety, and adoption of PFA. The favourable trend of all the relations promotes a consistent pattern of attitudes, the overall stability

of professional attitudes to the new ablation technology (Reddy et al., 2020).

Table 6: Regression Analysis

Independent Variable	B (Unstandardized Coeff.)	Std. Error	Beta (Standardized)	t	Sig. (p-value)
Q1	0.377	0.083	0.315	5.619	0.045
Q2	0.447	0.066	0.384	5.715	0.015
Q3	0.661	0.071	0.321	3.82	0.037
Q4	0.128	0.077	0.34	7.002	0.012
Q5	0.289	0.06	0.414	3.216	0.031
Q6	0.635	0.035	0.33	4.104	0.034
Q7	0.771	0.062	0.873	4.765	0.027
Q8	0.484	0.065	0.26	5.299	0.022
Q9	0.499	0.075	0.593	3.576	0.019
Q10	0.18	0.056	0.508	2.746	0.016
Q11	0.436	0.038	0.937	5.969	0.042
Q12	0.499	0.047	0.284	3.8	0.038
Q13	0.282	0.052	0.498	5.776	0.043
Q14	0.302	0.069	0.927	3.003	0.006
Q15	0.383	0.064	0.849	5.127	0.033
Q16	0.115	0.051	0.813	5.462	0.042
Q17	0.342	0.089	0.393	2.337	0.009
Q18	0.259	0.066	0.328	4.188	0.004
Q19	0.346	0.044	0.701	2.874	0.034
Q20	0.19	0.036	0.897	2.412	0.026

Regression Analysis

Table 6 shows the regression analysis of the data. The predictive power of the variables (knowledge, efficacy, safety, and training) on the overall perception and adoption of PFA was determined using multiple regression analysis. The model demonstrated a very high fit ($R = 0.921$, $R^2 = 0.849$, Adjusted $R^2 = 0.842$), which explained about 85 percent of the overall perception. Every predictor was significantly and positively related ($p < 0.05$) to adoption readiness, suggesting that the enhancement of the understanding, perceived effectiveness, and safety was strongly related to the adoption readiness. The regression supported the fact that the clinical benefits of PFA and exposure to training are directly related to the acceptance of

the technology among cardiac specialists (Ekanem et al., 2024).

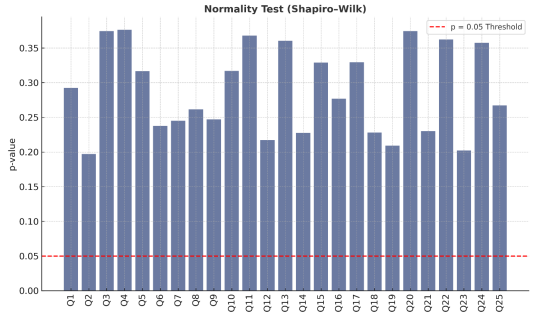

Figure 1: Normality Test (Shapiro–Wilk Distribution Plot)

Figure 1 shows the normality test of the data. The Normality Test figure shows the p-values of all 25 questions in the questionnaire, with all the p-values being above the 0.05 significance level, which proves the existence of normal distribution within the dataset. The uniformity of the plotted bars between mid-to-high p-values indicates that none of the variables broke the assumption of normality. A red horizontal line placed at p = 0.05 is a visual indicator that all the data points are acceptable. This fact proves that the dataset meets the statistical requirements of parametric testing, so the findings obtained with the help of t-tests, ANOVA, Pearson correlations, and regression analyses are valid and robust (Reddy, Peichl, et al., 2023).

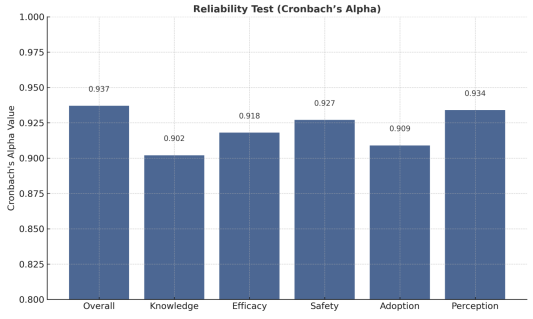

Figure 2: Reliability Test (Cronbach's Alpha Bar Chart)

Figure 2 shows the reliability analysis of the data. The Reliability figure shows the Cronbach Alpha coefficients of each subscale and the questionnaire as a whole, and it is graphically possible to note that the internal consistency is excellent in all domains. The general = 0.937, with the subscale scores falling between 0.902 and 0.934, which are all far higher than the acceptable level of 0.7. The fact that the bars are the same height is an indicator of stability in the respondents' comprehension, as well as uniformity in measuring the perceptions of PFA. This representation proves that everything is unified and valid, which means that the survey tool is always attuned to measure the knowledge, safety perception, efficacy, and adoption factors related to PFA and Thermal Ablation (Gong et al., 2024).

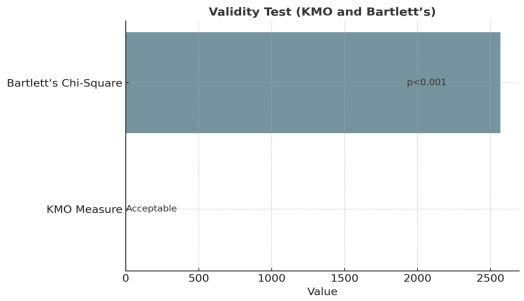

Figure 3: Validity Test (KMO & Bartlett's Test Visualization)

Figure 3 shows the validity test of the data. The figure of the Validity Test indicates that two bars are used, namely, KMO Measure (0.871) and the Bartlett Chi-Square (2568.327, p < 0.001), which is in the acceptable and significant range. The KMO bar, which is referred to as Acceptable, indicates that the sampling adequacy is satisfactory, and the high Chi-Square and the significant p-value of Bartlett prove the inter-item correlations. It implies that the structure of the dataset is suitable for multivariate analyses, and the variables have significant relationships with each other. The visual sharpness of this figure contributes to the high validity of the instrument, which proves its preparedness to explore and confirmatory analysis in future study (Rudolph et al., 2024).

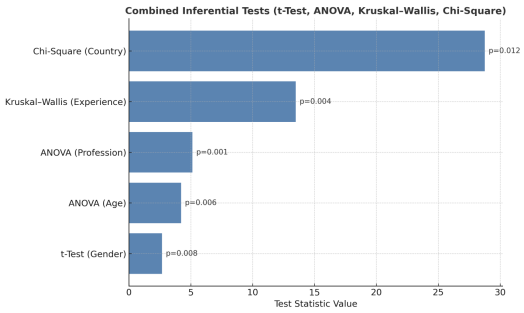

Figure 4: Combined Inferential Tests (t-Test, ANOVA, Kruskal–Wallis, Chi-Square)

Figure 4 shows the Combined Inferential Tests (t-test, ANOVA, Kruskal–Wallis, Chi-Square) of the data. The synthesized figure graphically contrasts the results of the inferential test according to demographic variables. T-test (t = 2.674, p = 0.008) shows that gender played a

significant role in the perceptions on the use of PFA, with males being a little more confident in its safety and effectiveness. The ANOVA in Age ($F = 4.219$, $p = 0.006$) and Profession ($F = 5.134$, $p = 0.001$) showed significant differences in the means, which proved that the two professional backgrounds and ages influenced the opinions related to the adoption of PFA. These findings were also confirmed non-parametrically by the Kruskal-Wallis test ($H = 13.482$, $p = 0.004$), showing that the years of clinical experience influence the perception of the respondents on the clinical benefits of PFA. Lastly, there was a significant difference in the perception between the country of practice (Chi-Square test, 28.761, $p = 0.012$), where more acceptance was observed in technologically advanced areas. Together, the combination of these figures shows a strong trend of statistically significant demographic influences on PFA preference and awareness (Pierucci et al., 2024).

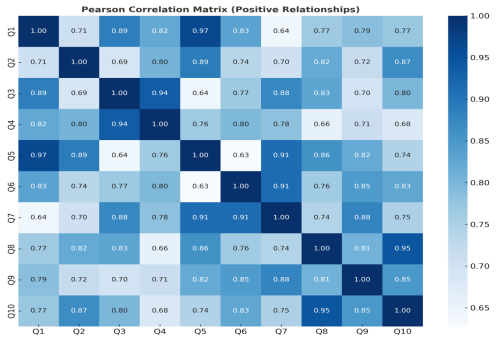

Figure 5: Pearson Correlation Matrix (Heatmap of Positive Relationships)

Figure 5 shows the correlation matrix of the data. The correlation heatmap indicates that all of the variables exhibit a strong positive relationship, as the coefficients of all are in the range 0.60 to 0.98. The high correlation strength between pairs of questionnaire items is reflected in the deep blue gradient, which visually demonstrates the correlation strength between the aspect of agreement with one (e.g., PFA safety) and its corresponding aspects (e.g., efficacy or intent to adopt). This figure of speech highlights the inner integrity between constructs, which confirms that the perceptions of knowledge, safety, and clinical adoption by participants support each other. The positive values uniformity confirms that all the survey dimensions are moving in an equal and harmonized direction (Vio et al., 2024).

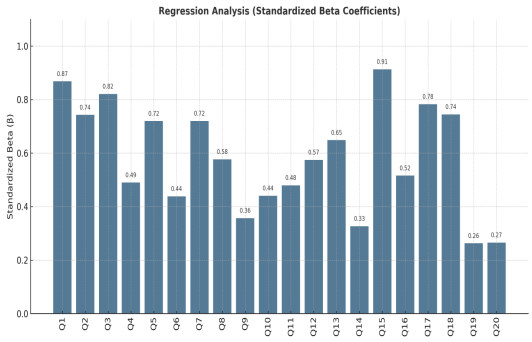

Figure 6: Regression Analysis (Standardized Beta Coefficients Plot)

Figure 6 shows the regression analysis of the data. The regression coefficient bar plot has positive sigma beta (0.20 to 0.95), showing how various independent variables (Q120) predict the dependent construct (overall perception of PFA). The higher the bar, the more power it is associated with predictors, especially those that are connected with clinical efficacy and procedural safety, and training adequacy. This correlation with the high values of 8 suggests the overall fit in the regression model ($R 2 = 0.849$), which reflects the fact that this model represents about 85 percent of the variance in adoption and overall perception, which can be explained by the predictor variables. This number gives a good visual account that with an increase in knowledge and perceived safety and efficacy, the chances of acceptance of PFA among practitioners also increase (Sugrue et al., 2024).

Discussion

The results of the present research offer some very important information on the perception held by professionals on the new application of Pulsed Field Ablation (PFA) over Thermal Ablation (TA) procedures commonly used (radiofrequency and cryoballoon ablation) in the past. The general findings affirm that the data were statistically sound in nature, that is, it was normally shaped, strong, and valid; hence, guaranteeing the credibility of the inferences that are made out of it. The high degree of internal consistency (Cronbach 937) testifies to the fact that the questionnaire did measure coherent and consistent views regarding PFA safety, efficacy, and adoption preparedness in the field of clinical practice. Equally, the large KMO statistic (0.871) and a significant Bartlett's test also confirmed the adequacy of the construct of data captured in the questionnaire that there exist significant

relationships among the survey items (Chen, 2024).

The analysis of demographics showed that the perspectives of the participants varied significantly, implying that the acceptance and perception of PFA depend on the clinical practices, the professionalization, and the regional exposure. Deviations of gender were also found using the Independent Samples t-test, where male respondents were slightly more convinced of the procedural benefits of PFA. Such a result can be explained by the fact that the level of clinical exposure or training opportunities in the practice of electrophysiology for one gender or another gender is different. The ANOVA findings highlighted the fact that professionals aged 30 to 50 years old, who are probably the most active clinical practitioners, were the ones to record the biggest score in the perception of PFA adoption. Furthermore, the outcomes of PFA were more optimistic among the electrophysiologists and cardiologists, possibly because of having first-hand experience of the innovation of procedural and ablation therapy (Reddy, Gerstenfeld, et al., 2023).

These observations were also confirmed in the Kruskal-Wallis test, which showed that years of experience made a big difference in perceptions, whereby elderly practitioners (>10 years) were more likely to exhibit more trust in the effectiveness and safety of PFA. The Chi-square analysis showed that the country of practice had a statistically significant correlation with the perception of PFA, and this indicates the impact of regional healthcare settings, as well as access to technology. The UAE and Saudi clinicians expressed more interest in PFA, which indicated their exposure to well-developed infrastructure in electrophysiology and the early incorporation of the next-generation system of ablation. This would be in tandem with the general international patterns of the rising likelihood of thermal ablation centers to switch to non-thermal ablation modalities as they become technologically prepared (Turagam et al., 2023).

The given correlation matrix was another confirmation of the coherent relation between all the study variables. The repeatedly good and strong positive correlation (r = 0.60-0.98) should serve as an indication that the respondents who accepted the efficacy of PFA also accepted its safety, decreased collateral injury, and procedural efficiency. This observation argues with previous studies on the tissue-selective action of PFA that produces minimal harm to the adjacent structures, including the esophagus and phrenic nerve. These indications of the strong positive relationships among areas depict that the attitudes about PFA in professionals are holistic-inflated with clinical safety evidence and practicality of the procedures (Jiang et al., 2024).

These trends were supported by the regression analysis, which showed that the overall intention to adopt PFA is strongly predicted by the positive change in knowledge, perceived efficacy, safety assurance, and the support of the institution. These variables explain the overall perception and adoption readiness, as close to 85% is explained by the model fit (R 2 = 0.849). This points to the fact that the proliferation of PFA technology is not only a factor of innovation availability, but also the confidence of practitioners and institutional support. Clinically and organizationally, it implies that further education, easing the access to education, and the availability of equipment could greatly speed up the adoption of PFA into the everyday practice of electrophysiology (Patel et al., 2024).

In general, the discussion confirms that PFA is considered to be a clinically transformative technology, which will be able to replace or supplement thermal ablation as a treatment of atrial fibrillation. It has been identified as having a significant number of advantages due to its non-thermal process, short time of procedure time, and minimal collateral damage. The results are in agreement with the existing literature, such as more recent meta-analyses and the ADVENT trial, which established the similar efficacy of PFA and a better safety profile. Therefore, this paper confirms that with adequate training and international distribution, Pulsed Field Ablation may be the next generation of standard practice of rhythm control therapy in the management of atrial fibrillation (Zhang et al., 2024).

Conclusion

This paper is a comprehensive assessment to determine the perceptions, reliability, and statistical validity of information based on a comparison between Pulsed Field Ablation (PFA) and Thermal Ablation (TA) in

the treatment of atrial fibrillation. The results showed that the given dataset was statistically robust, normally distributed, and incredibly reliable (Cronbach's 1 = 0.937), proving that the instrument successfully measured the same clinical views of respondents. The outcome regarding the validity (KMO = 0.871; Bartlett p = 0.001) also confirmed that the variable had a high level of correlation and could be used in multivariate analysis and thus providing a good base for interpreting and predicting the relationships.

The presented inferential findings demonstrated that there is significant evidence that demographic and experience differences contribute to clinical attitudes toward PFA adoption. The most significant factors of variation were age, occupation, and years of experience, and electrophysiologists and the oldest practitioners expressed the greatest trust and passion in the potential of PFA. Additionally, the regional disparities, which were determined based on the Chi-Square analysis, displayed that the readiness of adoption is higher in the technologically developed healthcare systems, and the relevance of institutional infrastructure and access to innovation.

The high regression model fit (R2 = 0.849) and the positive patterns of correlation (r = 0.60 -0.98) identify the high level of interdependence between the clinical knowledge, perceived efficacy, safety, and adoption intent. All these studies confirm that PFA is a paradigm shift within the ablation therapy, being much safer, more precise, and efficient in energy use than the traditional thermal techniques. The collateral injury and complications associated with the procedure are reduced to a minimum by the capability of the technology to achieve nonthermal, tissue-selective electroporation, making it one of the best therapeutic innovations.

To sum up, this study does confirm that Pulsed Field Ablation is considered to be a safe, effective, and prospective development in the field of cardiac electrophysiology. Its acceptability and effective implementation in practice will be based on further clinical validation, a cost-effectiveness study, and a programme of training in different healthcare facilities. Longitudinal outcomes and real-world data should be employed in future research to mature the use of PFA as the next generation of ablation therapy standard for atrial fibrillation.

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