Mobile Health Technology for Atrial Fibrillation Management Integrating Decision Support, Education, and Patient Involvement

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DOI:
10.1016/j.amjmed.2017.07.003

Document Version
Peer reviewed version

Citation for published version (Harvard):
Guo, Y, Chen, Y, Lane, D, Liu, L, Wang, Y & Lip, G 2017, 'Mobile Health Technology for Atrial Fibrillation Management Integrating Decision Support, Education, and Patient Involvement: mAF App Trial', *The American Journal of Medicine*, vol. 130, no. 12, pp. 1388-1396.e6. https://doi.org/10.1016/j.amjmed.2017.07.003

Mobile Health (mHealth) technology integrating clinical decision support and patient involvement for the management of patients with atrial fibrillation: The mAFA (mAF-App) randomized trial

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ABSTRACT

BACKGROUND: Mobile Health (mHealth) technology is increasingly proposed for cardiovascular disease management. The feasibility, efficacy and safety of mHealth technology for the management of patients with atrial fibrillation (AF) is unknown. We perform a randomized, controlled trial (mAFA; Clinical Trials Registry number: ChiCTR-IOR-17010436) of a mHealth technology-supported AF management model, integrating clinical decision support tools, guideline-based treatment, and patient involvement.

METHODS: The simple mAF (mobile AF) App was designed, incorporating clinical decision support tools (CHA_2DS_2-VASc, HAS-BLED, SAMe-TT_2R_2 scores), educational materials, and patient involvement strategies with self-care protocols and structured follow-up. AF patients were randomized into two groups (mAF App vs usual care) in a cluster randomized design, based in 2 hospitals: Chinese PLA General hospital, Meishan City People's Hospital, between January 1, 2017 and May 1, 2017. Patient's knowledge, Quality of Life (QoL), drug adherence, and Anti-Coagulation Satisfaction were evaluated at baseline, 1 month, and 3 months. Usability, feasibility, acceptability of the mAF App was assessed at 1 month.

RESULTS: 113 patients were randomized to mAF App intervention (mean age 67.4 years, 57.5% male, mean follow-up 69 days), while 96 patients were randomized to usual care (mean age 70.9 years, 55.2% male, mean follow-up 95 days).

Over 90% of patients reported that the mAF App was easy, user-friendly and helpful, associated with significant improvements in knowledge, compared to the usual care arm (p values for trend, <0.05). Drug adherence and anti-coagulant satisfaction were significantly better with the mAF App vs usual care (all p <0.05). QoL scores were significantly increased in the mAF App arm vs usual care, with anxiety and depression reduced (all p<0.05).

CONCLUSION: The mAFA trial is the first prospective randomized trial of mHealth technology in patients with AF, demonstrating that the mAF App, integrating clinical

decision support, education, and patient involvement strategies, significantly improved knowledge, drug adherence, QoL and anticoagulation satisfaction.

KEYWORDS: atrial fibrillation, mobile health, patient education, drug adherence

Atrial fibrillation (AF) is most common cardiac arrhythmia, with global health burden of about 33.5 million individuals with AF worldwide[1]. The lifetime risk for developing AF is 21%-23% in women, and 17%-26% in men[2-4]. In the past five decades, age-adjusted AF prevalence globally has increased fivefold[5], and is expected to double by 2050[1]. AF-related stroke is devastating, which has been described as a "AF-related stroke tsunami" without proper treatment with oral anticoagulants (OAC)[6].

The underutilization or inappropriate use of OAC is common in the AF population, and particularly so in many Asian countries[7]. Even in the new era of non-vitamin K antagonist oral anticoagulant (NOAC), many patients remain undertreated, particularly in Asia and North America[8]. Also, 28% of high-risk patients (defined as a CHA_2DS_2-VASc score ≥2) are not anticoagulated, while 51% of very-low patients were inappropriately anticoagulated[9].

Nonadherenc to AF guidelines is common across all risk strata, ranging from 33% to 68% (Middle East/Africa and Asia, respectively) among the high-risk population[10]. On the other hand, patient's preferences are another important reason for non-adherence of therapy[11]. Thus, efforts to streamline decision-making for stroke prevention in patients with AF and improve the patient's knowledge are important in the era of NOACs[12].

Novel strategies that incorporate eHealth or mobile Health (mHealth) encompasses the use of information and communication technologies in the management of disease, providing innovative solutions to the problem of long-term management after discharge[13,14]. However, there are limit data on implementation of mHealth technology for the management of patients with AF, particularly in relation to its feasibility, efficacy and safety.

Our aim was to perform a randomized, controlled trial (mAFA; Clinical Trials

Registry number: ChiCTR-IOR-17010436) of a mHealth technology-supported AF management model, integrating clinical decision support tools, guideline-based treatment, and patient involvement. The mAFA trial is the first prospective randomized trial of mHealth technology in patients with AF.

MATERIALS AND METHODS

A user-friendly mAF App (mAFA) was developed for smart phones based on Android Operating System and Apple iOS, which incorporated clinical decision support (clinical risk scores, ie. CHA_2DS_2-VASc, HAS-BLED, and SAMe-TT_2R_2 score), patient educational programs, patient involvement self-care components, and structured follow-up components.

AF patients were randomized to two groups (mAF App vs usual care) in a cluster randomized design, based in 2 hospitals: Chinese PLA General hospital, Meishan City People's Hospital, between January 1, 2017 and May 1, 2017. Inclusion criteria included adult AF patients aged over 18 years old, diagnosed with ECG, 24 hour Holter. We excluded individuals aged <18 years, those with valvular AF (prosthetic, etc.) or unable to provide written informed consent (Supplementary Figure 1, available online).

Patient's knowledge, Quality of Life (QoL), drug adherence, and Anti-Coagulation Satisfaction were evaluated at baseline, 1 month, and 3 months. Usability, feasibility, acceptability of the mAF App was assessed at 1 month.

Design of mAF App

The mAF App was designed with versions for patients (P mAF App) and doctors (D mAF App) respectively. The mAF App incorporates details such as the Personal Health Record (PHR), stroke and bleeding risk assessment (CHA_2DS_2-VASc and HAS-BLED scores, respectively), and a clinical score to aid warfarin control prediction (SAMe-TT_2R_2), patient educational programs, patient involvement self-care items, and structured follow-up components.

PHR The mAF App could record AF features, patient medical history, laboratory tests, AF treatments, antithrombotic drugs and other pharmacological treatments at baseline. Patients were recommended to upload their laboratory tests (hemoglobin,

platelet count, liver/renal function tests, blood lipids, etc.), electrocardiogram (ECG), and echocardiogram (if available), at 1 month and 3 months after their initial consultation.

Clinical decision support The mAF App automatically calculates CHA_2DS_2-VASc, HAS-BLED and SAMe-TT_2R_2 scores, after the patient's PHR was completed (Supplementary Figure 2, available online).

Patients with low stroke risk (CHA_2DS_2-VASc score 0 in males, 1 in females) were recommended no antithrombotic treatment. The patients at moderate stroke risk (1 stroke risk factor) were suggested to consider OAC balancing against bleeding risk, while those at high stroke risk (CHA_2DS_2-VASc $\geq$2) were recommended OAC. Patients with HAS-BLED $\geq$3 were flagged for follow-up and modifiable bleeding risk factors were proactively addressed. As NOACs are 'self-pay' drugs and not reimbursed in China, if the patients had a SAMe-TT_2R_2 score 0-2, they were considered to receive warfarin treatment. If the SAMe-TT_2R_2 score was >2, the patients would have additional education/counseling about warfarin and more regular review/ international normalized ratio (INR) checks, or to use a NOAC.

Patient's educational program There were eight components of the patient's educational program, with additional patient self-support items. Patients followed the educational program on mobile to improve their knowledge of AF and learn how to manage themselves at home. The AF educational programs included the following parts: Part 1 "What is AF"; Part 2 "AF and stroke/thromboembolism"; Part 3 "Anticoagulant therapy in AF"; Part 4 "AF ablation"; Part 5 "Safe drug therapy"; Part 6 "High risk population: what is the left atrial appendage occlusion?"; Part 7 "AF and coronary artery disease"; and Part 8 "AF, pulmonary thrombosis, and deep vein thrombosis" (Supplementary Figure 3, available online). Patient's knowledge and understanding was assessed at baseline, 1 month, and 3 months using a 11-item questionnaire regarding AF[15].

Patient involvement with self-care The patients were encouraged to monitor their heart rate and blood pressure, and feedback on their treatment using the mAF App (Supplementary Figure 4, available online). Their quality of life (QoL) was assessed using Euro EQ-5D-Y at baseline, 1 month, and 3 months.

Structured follow-up Structured follow-up was planned at 1, 3, 6, 9, 12 months after consultation/discharge, and included assessment of drug therapy, thrombotic events, bleeding events, QoL, OAC satisfaction, and mAF App investigations (Supplementary Figure 5, available online). A reminder 'alert' was sent automatically to patients one week before and after the follow-up timepoint by the mAF App.

The patients' drug adherence was assessed on baseline, 1 and 3 months with the Pharmacy Quality Alliance (PQA) adherence measure, with a 3-item Adherence Estimator (perceived need for medications, perceived concerns about medications, and perceived medication affordability; Low risk=score 0, Medium risk=score 2-7, and High risk=score 8-36)[16].

The Anti-Clot Treatment Scale (ACTS) was adapted to evaluate the satisfaction of patients with OAC in this Chinese population with AF. The adapted ACTS included a 15-item questionnaire, comprising 11 burden items and 4 benefit items. For every question, there are five item responses. "1, Not at all" was calculated as 1 point; "2, A little" was calculated as 2 points; "3, Moderately" was calculated as 3 points; "4, Quite a bit" was calculated as 4 points; and "5, Extremely" was calculated as 5 points (Supplementary Table 1, available online).

Data Management, Quality Control, Data Security and Ethics

Users had a user-sensitive password for access to their mAF App. PHR were stored as structured data on a cloud platform. For example, the medical records and lab tests could be uploaded to mAF App as image file, then the image files were transferred

into structured data with optical character recognition technology. Two persons independently double checked the structured data and the source documentation (ie. the image files of lab test, medical record, etc.) for consistency and accuracy, to achieve good quality control of data management.

Health Insurance Portability and Accountability Act (HIPAA) requirements was adopted to confirm data security during data transfer and data storage, in terms of the Administrative Procedures, Physical Safeguards, Technical Security Services, and Technical Security Mechanisms. Data input into analysis was performed by two individuals, who were blinded for the intervention groups. Data was double checked independently by a third investigator. Patient records/information was anonymized and de-identified prior to analysis.

The Medical Ethics Committee of PLA General Hospital and the China Food and Drug Administration (CFDA) (Registry number: XZF20120145) approved the present study protocol (Approval number: S2016-086-01). The present study was registered in Chinese Clinical Trial Registry, International Clinical Trials Registry Platform of WHO (ChiCTR-IOR-17010436).

Statistical Analysis

Continuous variables were tested for normality by the Kolmogorov-Smirnov test. Data with a normal distribution are presented as a mean (standard deviation, SD) and analyzed using t test. Data with a non-normal distribution are presented as median (inter-quartile range, IQR). The comparison of discrete variables was performed using the chi-square test.

The usability, feasibility, acceptability of mAF App were investigated at 1 month. The questionnaire included the following: i) Do you think that the mAF App is easy and user-friendly?; ii) Are you familiar with the main functions of mAF App?; iii) Do you have good real-time communication with physicians using the mAF App?; and iv) Do

you think that the mAF App is effectively helpful for self-care management? Their satisfaction rate was calculated.

Data on patient' knowledge, QoL scores, antithrombotic drugs and other drugs at the three time-points (baseline, 1, and 3 months) were presented graphically to illustrate the change in these variables over time between the mAF App and usual care groups. Trends of improvement of patient's knowledge at baseline, 1 month, and 3 months was analyzed with Cochran's and Mantel-Haenszel statistics.

Patient's adherence to drug therapy was calculated using the 3-item Adherence Estimator scores, comparing patients with usual care and mAF App, and was analyzed with Mann-Whitney U test.

Comparative analysis of ACTS and QoL questionnaire scores (EuroQol, EQ-5D-Y) between patients with usual care and mAFA was performed using t-tests, and the chi-square test was utilized for comparisons of improvement of mobility, self-care, usual activities, pain/discomfort, and anxiety/depression on baseline, 1 month, and 3 months.

A sample size of 112 patients (56 in each group) allows for a 20% attrition rate in the completion of the questionnaires, and would have at least 80% power to detect an 18.5% increase in knowledge about the condition between baseline and follow-up[17]. A beta = 0.20 and alpha=0.05 were assumed.

A p value <0.05 was considered as statistically significant. The 95% confidential interval (CI) were calculated based on Poisson distribution. Statistical analysis was performed using IBM SPSS Statistics version 21.0 (SPSS, Inc., Chicago, Illinois).

RESULTS

In a cluster randomization design, 113 patients were randomized to mAF App intervention (mean age 67.4 years, 57.5% male) with mean follow-up of 69 days, while 96 patients were randomized to usual care (mean age 70.9 years, 55.2% male) with mean follow-up of 95 days. Of the original cohort, 113 patients with mAF App had 1-month follow-up and 71 patients finished the 3-month follow-up; 96 patients with usual care had 1-month, and 3-month follow-up visits.

Hypertension, coronary artery disease (CAD), diabetes, and heart failure were the most common comorbidities in both groups (Table 1). The patients with mAF App had more prior AF ablation therapy (p=0.036).

Usability, Feasibility, Acceptability of mAF App

Over 90% patients agreed that the mAF App was easy, user-friendly and helpful, while they had good feedback with the doctors on the mAF App (Supplementary Figure 6, available online).

Patient's Knowledge on AF

The knowledge was improved greatly in the patients with mAF App over time (all $p < 0.05$), while was not seen in the patients with usual care (Figure 1).

Qol Improvement on Patients with mAF App

QoL scores were significantly increased in the mAF App arm compared to usual care at baseline, 1, and 3 months (all $p<0.05$) (Figure 2). Self-care improved significantly over time with mAF App, but not in usual care (all $p<0.05$). Anxiety and depression also tended to be ameliorated for patients using mAF App compared to usual care over time (all $p<0.05$) (Table 2).

Drug Adherence to Therapy

Compared to patients with usual care, drug adherence was significantly better with the mAF App at 1 month and 3 months (all $p < 0.05$) (Table 3).

Patients with mAF App were more likely to receive NOACs, ranging from 40.7% to 44.2%, compared to those with usual care ($p<0.001$). There was a slight increase of NOAC use (3.52%) over time in patients using mAF App (Figure 3). Secondary prevention of comorbidities for AF was much improved in patients with mAF App compared to patients with usual care (Supplementary Figure 7, available online).

Anti-coagulation Satisfaction

Patients with usual care expressed more anticoagulant 'burden', while patients with mAF App reported more anticoagulant 'benefit' (all $p<0.05$) (Table 4).

DISCUSSION

To our knowledge, the mAFA trial is the first prospective randomized trial of mHealth technology in patients with AF, demonstrating that the mAF App, integrating clinical decision support, education, and patient involvement strategies, significantly improved knowledge, drug adherence, QoL and anticoagulation satisfaction.

Clinical decision support provided by the mAF App streamlined guided-based decision-making for the stroke prevention in patients with AF, and was easily handled by doctors and understood by patients. The clinical decision support tools in the mAF App automatically assessed stroke and bleeding risk, stratified the patients with high-risk stroke/TE to anticoagulant treatment, while balancing the bleeding risk. Bleeding risk factors were also labeled, and could be reviewed by doctors and patients. Personalized choice of OAC would also be advised based on the SAMe-TT_2R_2 score, resulting in rational decision-making on anticoagulant management options.

Suboptimal thromboprophylaxis in AF patients is highly prevalent, contributed by an inappropriate evaluation of the risks versus benefits of OAC, despite various guidelines on AF management[18,19]. Indeed, guideline-adherent antithrombotic management is associated with significantly better outcomes[20]. One barrier to adherence to guideline-optimised therapy could be the challenges of a “real-world” busy clinical practice, and the clinical decision-making tool in the mAF App could make the process of guideline implementation much easier and simple.

To help access to guidelines for the *clinician*, a pocket guideline app for European guidelines has been developed, and CATCH-ME treatment manager is integrated into the AF section, but has yet to be prospectively tested[21]. Another option is the Atrial Fibrillation Decision Support Tool (AFDST), which is a patient-specific decision analytic model comprised of a 29-state Markov simulation, using information from

the EHR to integrate patient-specific risk factors for stroke and hemorrhage in its calculations[22]. However, the intervention with AFDST did not result in significant improvements in discordant antithrombotic therapy in an AF population[23]. Other apps are also developed to provide stroke and bleeding risk calculations, for example, the Computerised Antithrombotic Risk Assessment Tool Version 2 (CARATV2.0) could calculated the $CHADS_2$, CHA_2DS_2-VASc, HAS-BLED and $HEMORR_2$- HAGES scores[24]. Another clinical decision support tool, which could calculate CHA_2DS_2-VASc score and alter the clinician prescription of OAC therapy, is being studied[25]. However, these apps/tools are focused on doctors, and not for the follow-up and day to day management of AF patients.

The mAF App not only calculates the clinical risk scores, but also automatically makes a follow-up plan, permitting patient's self-monitoring and timely feedback. We also show that the mAF App-based self-monitoring and feedback also enhanced compliance and adherence of drug therapy and anti-coagulant satisfaction. With the planned follow-up by mAF App, the clinician gets the patient's updated clinical condition, re-evaluates their clinical risk profile (especially since stroke and bleeding risk is not static) and regulates the dosage and usage of various drugs. Meanwhile, the patients clarified their questions, gets involved in their self-management, and benefits overall from their treatment plan.

Indeed, clinical follow-up ensures the effective and safe anticoagulant therapy in AF patients. Systematic review of drug's adherence, thromboembolism, bleeding events, any adverse effects, renal or hepatic function, etc. are recommended for NOACs[26,27], eventhough anticoagulation tests are not needed. In one study, about two-thirds of practitioners adhered to recommendations on clinical and blood test (creatinine and haemoglobin) follow-ups[28]. Clinical risk monitoring is important particularly for bleeding risk management after discharge/prescription of NOACs, and the mAF App allows a practical tool to monitor the patient's clinical risk profile in 'real time' allowing a dynamic assessment (and re-assessment) of patient risks and changes over

time. Moreover, the educational programs provided by the mAF App improved AF-related knowledge and patient's QoL. Patient anxiety and depression was also attenuated.

Contemporary AF clinical guidelines advocate incorporation of patient preferences for treatment and support as well as patient engagement in management decisions[21,29]. Nonetheless, patient beliefs and misconceptions existing their treatment and AF could impact on their ability and willingness to adhere to treatment recommendations [29]. A prior study has confirmed that a bespoke education intervention significantly improved anticoagulation control of warfarin[30]. A higher patient education level has been associated with NOAC selection[31]. The mAF App provides the specific educational components, in terms of warfarin, NOACs, specific conditions, etc., that may help patients for self-management.

Study Limitations

Some limitations of this study need to be addressed. This was clustered randomized study, and the selection bias could exist. However, the distribution of comorbidities between mAF App and usual care arms were not significantly different. Moreover, the clinician's preference for OAC may have contributed to higher rate of NOAC use in the mAFA group. However, the educational program could make the patients more aware, and be more likely to receive NOACs. Furthermore, the impact on the clinical outcomes (stroke, death, bleeds) of mAF App is needed to be ascertained in a long term prospective study, which was not the objective of the present study.

Despite these limitations, the present study shows that the clinical decision support, evidence-based clinical follow-up, and patients' involvement in self-care can help clinical management for the AF population, highlighting an effective mHealth-support managemental strategy.

CONCLUSIONS

The mAFA trial is the first prospective randomized trial of mHealth technology in patients with AF, demonstrating that an approach integrating clinical decision support, education, and patient involvement strategies, would translate to significantly improved knowledge, drug adherence, anti-coagulant satisfaction, and QoL.

ACKNOWLEDGMENTS

Our sincere thanks to the Mr. Rujuan Liao, Chinese PLA General hospital, who oversaw the data input and quality checks. We are also grateful of Xiaoyu Tang, for the recruitment of participants.

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Funding: This research project was funded by Chinese PLA Healthcare Foundation (13BJZ40), Beijing Natural Science Foundation (7142149), Beijing Natural Science Foundation (Z141100002114050), and National Natural Science Foundation of China (H2501).

Author Contributions

Y.G. and G.Y.H.L. are guarantors of the manuscript and contributed to the original idea, data analyses, and manuscript drafting and revisions. Y.C., D.A.L., L.L., and Y.W. contributed to the manuscript drafting and revisions. All of the authors reviewed and approved the final manuscript.

Conflict of Interest: GYHL: Consultant for Bayer/Janssen, BMS/Pfizer, Biotronik, Medtronic, Boehringer Ingelheim, Microlife and Daiichi-Sankyo. Speaker for Bayer, BMS/Pfizer, Medtronic, Boehringer Ingelheim, Microlife, Roche and Daiichi-Sankyo. No fees are received personally. Other authors: None declared.

Authorship: All authors had access to the data and played a role in writing this manuscript.

FIGURE LEGENDS

Figure 1 Patient's knowledge on AF with usual care and mAF APP on baseline, 1 month, and 3 months. * p for trend on baseline, 1 month, and 3 months after discharge, <0.05.

Figure 2 Time trend on QoL scores of patients with mAF App. * QoL questionnaire was cited from the EuroQol. Compared to patients with usual care, patients with mAF App, p<0.05.

Figure 3 Antithrombotic treatment in patients with mAF APP and usual care on baseline, 1 month, and 3 months after discharge. 3A Usual care. 3B mAF APP.

TABLES

Table 1 Baseline characteristics

	mAF App (n=113)		Usual care (n=96)		p
Age, mean(SD)	67.4	(10.6)	70.9	(17.4)	0.066
Male, n(%)	65	57.5%	53	55.2%	0.737
Medical history					
Hypertension, n(%)	71	62.8%	51	53.1%	0.156
CAD, n(%)	50	44.2%	42	43.8%	0.942
Diabetes mellitus, n(%)	21	18.6%	14	14.6%	0.440
Heart failure, n(%)	14	12.4%	18	18.8%	0.203
Prior stroke, n(%)	9	8.0%	9	9.5%	0.717
PAD, n(%)	8	7.1%	3	3.1%	0.202
Renal dysfunction, n(%)	8	7.1%	5	5.2%	0.577
Hypertrophic cardiomyopathy, n(%)	5	4.4%	1	1.0%	0.144
Liver dysfunction, n(%)	4	3.5%	1	1.0%	0.239
AF treatment					
AF ablation, n(%)	12	10.6%	3	3.1%	0.036
Dual chamber pacemaker, n(%)	7	6.2%	4	4.2%	0.513
Pharmacal cardioversion, n(%)	3	2.7%	2	2.1%	0.788
Electrical cardioversion, n(%)	0	0.0%	2	2.1%	0.123
LAAO, n(%)	1	0.9%	1	1.0%	0.908
CHA_2DS_2-VASc score	2.6	(1.5)	2.7	(1.6)	0.383
HAS-BLED score	1.4	(0.9)	1.6	(0.8)	0.053

* CAD：Coronary artery disease. PAD: Peripheral arterial disease. LAAO: Left atrial appendage occlusion.

Table 2 QoL questionnaire responses in patients with mAF App and usual care

	On discharge			1 month after discharge			3 months after discharge		
	mAF App	usual care	P	mAF App	usual care	P	mAF App	usual care	p
Mobility	(n=113)	(n=96)		(n=113)	(n=96)		(n=71)	(n=96)	
No problems	70.80%	26.04%	<0.001	76.36%	26.04%	<0.001	77.46%	27.08%	<0.001
Slight problems	23.89%	32.29%	0.180	15.45%	35.42%	0.001	15.49%	36.46%	<0.001
Moderate problems	5.31%	31.25%	<0.001	7.27%	31.25%	<0.001	5.63%	29.17%	<0.001
Severe problems	-	5.21%	0.014	-	2.08%	0.123	-	2.08%	0.221
Unable to walk about	-	5.21%	0.014	0.91%	5.21%	0.062	1.41%	5.21%	0.062
Self-care									
No problems	77.88%	55.21%	<0.001	83.64%	65.63%	<0.001	87.32%	68.75%	<0.001
Slight problems	18.58%	21.88%	0.449	15.45%	15.63%	0.908	11.27%	11.46%	0.272
Moderate problems	1.77%	9.38%	<0.001	-	8.33%	0.002	-	9.38%	0.001
Severe problems	1.77%	4.17%	0.301	-	2.08%	0.123	-	2.08%	0.221
Unable to wash or dress	-	9.38%	0.001	0.91%	8.33%	0.008	1.41%	8.33%	0.008
Usual activities									
No problems	69.91%	37.50%	<0.001	78.18%	45.83%	<0.001	77.46%	53.13%	<0.001
Slight problems	27.43%	30.21%	0.659	20.00%	27.08%	0.252	19.72%	18.75%	0.203
Moderate problems	2.65%	19.79%	<0.001	0.91%	16.67%	<0.001	1.41%	16.67%	0.001
Severe problems	-	3.13%	0.001	-	2.08%	0.123	-	3.13%	0.133
Unable to do usual activities	-	9.38%	0.001	0.91%	8.33%	0.008	1.41%	8.33%	0.050
Pain/discomfort									
No pain or discomfort	63.70%	35.42%	<0.001	59.09%	41.67%	0.016	63.38%	40.63%	0.006
Slight pain or discomfort	25.66%	39.58%	0.046	33.64%	41.67%	0.231	25.35%	45.83%	0.007

Moderate pain or discomfort	10.62%	20.83%	0.041	6.36%	12.50%	0.114	9.86%	10.42%	0.906
Severe pain or discomfort	-	1.04%	0.277	0.91%	2.08%	0.468	1.41%	1.04%	0.829
Extremely pain or discomfort	-	3.13%	0.058	-	2.08%	0.123	-	2.08%	0.221
Anxiety/depression									
No anxious or depressed	50.44%	52.08%	0.831	62.70%	62.50%	0.935	57.75%	61.46%	0.629
Slight anxious or depressed	40.71%	21.88%	0.005	31.82%	19.79%	0.048	32.39%	20.83%	0.091
Moderate anxious or depressed	8.85%	20.83%	0.014	5.45%	14.58%	0.023	9.86%	14.58%	0.363
Severe anxious or depressed	-	-	-	-	-	-	-	1.04%	0.388
Extremely anxious or depressed	-	5.21%	0.013	-	3.13%	0.058	-	2.08%	0.221

* QoL questionnaire was cited from the EuroQol.

Table 3 Drug adherence at baseline, 1 month, and 3 months

	mAF APP	Usual care	p
Baseline	n=113	n=96	
	4(4-11)	4(4-11)	0.870
1 month	n=113	n=96	
	0(0-4)	4(0-11)	<0.001
3months	n=71	n=96	
	2(0-4)	4(0-11)	<0.001

* Pharmacy Quality Alliance (PQA) adherence measures: 3-item Adherence Estimator. Low risk=score of 0, moderate risk=score of 2-7, and high risk=score of 8-36.

Table 4 Anti-Coagulation Satisfaction in patients with mAF App and usual care

	Usual care (n=46)		mAF APP (n=65)		p
Baseline					
Burden Scale, mean(SD)	20.83	(6.61)	17.58	(8.10)	0.028
Benefit Scale, mean(SD)	13.31	(3.39)	14.11	(3.65)	0.256
1 month	Usual care (n=44)		mAF APP (n=63)		p
Burden Scale, mean(SD)	19.40	(6.05)	16.04	(7.50)	0.018
Benefit Scale, mean(SD)	14.19	(3.18)	15.09	(2.38)	0.013
3 months	Usual care (n=45)		mAF APP (n=42)		p
Burden Scale, mean(SD)	19.30	(6.39)	15.57	(6.57)	0.008
Benefit Scale, mean(SD)	14.21	(3.37)	15.60	(2.73)	0.052

* Compared to the patients with usual care, $p<0.05$. The Anti-Clot Treatment Scale (ACTS) was adapted to evaluate the satisfaction of patients with anticoagulant therapy in this Chinese population with AF. The adapted ACTS included a 15-item questionnaire, comprising 11 burden items and 4 benefit items. For every question, there are five item responses. "1, Not at all" was calculated as 1 points. "2, A little" was calculated as 2 points, "3, Moderately" was calculated as 3 points. "4, Quite a bit" was calculated as 4 points. "5, Extremely" was calculated as 5 points.