

Structural Interventions

AMPLATZER™ PFO Occluder

CLINICAL INSIGHTS:

CLINICAL EVIDENCE FOR PFO OCCLUSION FOR RECURRENT STROKE
RISK REDUCTION USING THE AMPLATZER™ PFO OCCLUDER



Clinical Insights

A PUBLICATION DELIVERING CONCISE CLINICAL DATA

AMPLATZER™ PFO OCCLUDER

CLINICAL EVIDENCE FOR PFO OCCLUSION FOR RECURRENT STROKE RISK REDUCTION USING THE AMPLATZER™ PFO OCCLUDER

INTRODUCTION

Approximately one-third of ischemic strokes cannot be attributed to a source of definite cardioembolism, large artery atherosclerosis, or small artery disease despite extensive vascular, cardiac, and serologic evaluation¹. These strokes of undetermined mechanism account for an annual number of approximately 200,000 and 300,000 strokes in the US and the EU, respectively^{1,2}.

While a patent foramen ovale (PFO) is not considered a risk factor for stroke in general, its presence is commonly reported in patients with a stroke of undetermined mechanism. A meta-analysis of data from 22 studies showed that a PFO is more likely to be associated with such a stroke compared with stroke of determined mechanism (OR: 3.16, 95% CI: 2.30 – 4.35)³, with a strong association especially in patients younger than 55 years⁴. Paradoxical embolism through a PFO has been suggested as a mechanism leading to a stroke in the absence of established risk factors for ischemic stroke. Factors that may influence the risk for stroke in the setting of a PFO include the size of the PFO and the significance of shunting^{5,6}, the coexistence of an atrial septal aneurysm (ASA)³ and venous thrombosis⁷.

Given the mechanism of paradoxical embolism, PFO closure has been suggested as a secondary stroke prevention treatment in patients who suffered a stroke of undetermined mechanism. As younger patients are less likely to have established stroke risk factors, randomized trials on prevention of recurrent stroke by PFO closure have consistently enrolled patients younger than 60 years.

AMPLATZER PFO OCCLUDER

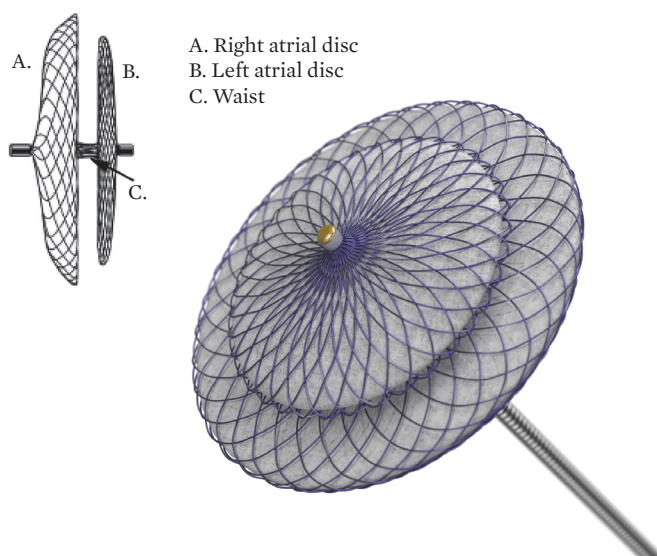
The AMPLATZER PFO Occluder was first implanted in September 1997 by Dr Kurt Amplatz and Dr Bernie Meier. The design of the device builds on extensive technological and clinical experience with the AMPLATZER portfolio of occlusion devices.

The AMPLATZER PFO Occluder consists of two self-expanding discs from Nitinol mesh, connected by a short waist (see Figure 1). The waist connecting the right atrial disc and the smaller left atrial disc allows free motion of each disc and is designed to

INDICATIONS AND USAGE

The AMPLATZER™ PFO Occluder is indicated for percutaneous transcatheter closure of a patent foramen ovale (PFO) to reduce the risk of recurrent ischemic stroke in patients, predominantly between the ages of 18 and 60 years, who have had a cryptogenic stroke due to a presumed paradoxical embolism, as determined by a neurologist and cardiologist following an evaluation to exclude known causes of ischemic stroke.

FIGURE 1



centralize the device within the PFO. The discs are designed to be introduced in the heart in a collapsed configuration, and will self-deploy at specific steps during the implantation procedure. To increase its closing ability, the device is filled with polyester fabric that is securely sewn to each disc by a polyester thread. Radiopaque marker bands are on the distal and proximal ends of the device. An end screw on the proximal end facilitates connection with the delivery cable during implantation.

RECENT CLINICAL EVIDENCE

Results from 3 large, randomized controlled trials using the AMPLATZER PFO Occluder and/or competitive devices have recently been reported (Table 1).

Among these trials, the RESPECT trial⁸ is the most extensive study with regard to the number of patients as well as follow-up duration. Medical therapy in the control group involved antiplatelets only (REDUCE and CLOSE trials^{9,10}) or antiplatelets or warfarin therapy (RESPECT trial⁸). Regarding patient inclusion, the CLOSE trial¹⁰ required the presence of an ASA or a significant right-to-left shunt, which constituted additional

TABLE 1: LARGE RANDOMIZED CONTROLLED TRIALS ON PFO CLOSURE WITH RECENTLY REPORTED RESULTS

	RESPECT ⁸	REDUCE ⁹	CLOSE ¹⁰
Study description	Multicenter randomized controlled trial of PFO closure versus medical treatment	Multicenter randomized controlled trial of PFO closure versus medical treatment	Multicenter randomized controlled trial of PFO closure versus medical treatment
Key inclusion criteria	Echocardiographic evidence of PFO, age ≤60 years	Echocardiographic evidence of PFO, age ≤60 years	PFO associated with ASA or large right-to-left atrial shunt, age ≤60 years
PFO closure therapy: Number of patients Mean age (years) Therapy	499 45.7 ± 9.7 AMPLATZER PFO occluder, APT for 6 months followed by antithrombotic therapy at the discretion of the site investigator	441 45.5 ± 9.3 Gore PFO occluders, APT	238 42.9 ± 10.1 CE-marked PFO occluders, DAPT for 3 months followed by single anti-platelet therapy for the remainder of the trial
Control: Number of patients Mean age (years) Therapy	481 46.2 ± 10.0 APT or warfarin therapy	223 44.8 ± 9.6 APT	235 (see note) 43.8 ± 10.5 APT
Follow-up (years) Total follow-up (patient years)	Median: 5.9 3141 (PFO) 2,669 (control)	Median: 3.2 1,529 (PFO) 703 (control)	Mean: 5.4 (PFO) / 5.2 (control) NR

(D)APT: (dual) antiplatelet therapy; ASA: atrial septal aneurysm; NR: not reported
NOTE: The CLOSE trial also compared APT with anticoagulation therapy (not included in this document).

requirements compared with the other 2 trials. Although this trial did not report results separately per device, the outcomes were dominated by the AMPLATZER PFO occluder, which was used in 51% of the procedures.

SAFETY

Key safety outcomes reported from the 3 trials are summarized in Table 2. Although the studies found variable numerical results regarding serious adverse event rates, none of the trials detected a significant difference between patients randomized to PFO closure or medical therapy.

The lowest incidence of new-onset atrial fibrillation (AF) was reported from the RESPECT trial. The incidence of AF outside of the periprocedural period was not significantly different between the PFO and control arms. Even when accounting for the separately reported 7 cases of periprocedural AF, the overall incidence of AF associated with the AMPLATZER device appears to be lower than with the GORE devices used in the REDUCE trial or the mix of devices used in the CLOSE trial. Similar observations, favoring the AMPLATZER PFO Occluder, were made from a meta-analysis including results of the CLOSURE I study (StarFlex Septal Closure System) and the PC trial and early results of the RESPECT trial (AMPLATZER PFO Occluder). Based on outcomes from all 3 trials, the risk of AF was significantly higher among patients treated with PFO closure compared with medical therapy (hazard ratio (HR): 3.22; p=0.0002)¹¹. With the analysis restricted to the AMPLATZER PFO Occluder, the difference in AF incidence was no longer

significant (HR: 1.85; p=0.12)¹¹. Both analyses (i.e. including data from all 3 trials, as well as data from AMPLATZER devices only) did not show a significant difference in bleeding rates between PFO closure and medical therapy¹¹.

Long-term follow-up of the RESPECT study showed a higher incidence of venous thromboembolism in the PFO group than in the medical therapy group. This difference was specifically prominent in patients with a history of deep venous thrombosis and may be explained by the lower usage of oral anticoagulants in the PFO closure group compared with medical therapy (3.3% vs. 21.6% of patient-years of follow-up).

CLINICAL OUTCOME

Both the RESPECT⁸ and REDUCE⁹ trials reported a marked reduction in the rate of all ischemic strokes after PFO closure, compared with medical therapy (see Figure 2). The difference in outcomes between these trials may be related to the different antithrombotic regimens (APT only in REDUCE versus APT or anticoagulants in RESPECT) and the different follow-up periods. Despite these differences, both trials underline the potential of PFO closure to reduce the risk of recurrent ischemic stroke in patients who experienced a stroke of undetermined mechanism. This potential was further demonstrated by a meta-analysis of results reported from the CLOSURE I study, the PC trial and early results of the RESPECT trial. This analysis showed that PFO closure achieved a significant reduction in stroke rate compared with medical therapy, when including data from all 3 trials (42% reduction) and data obtained with the

TABLE 2: SAFETY OUTCOMES

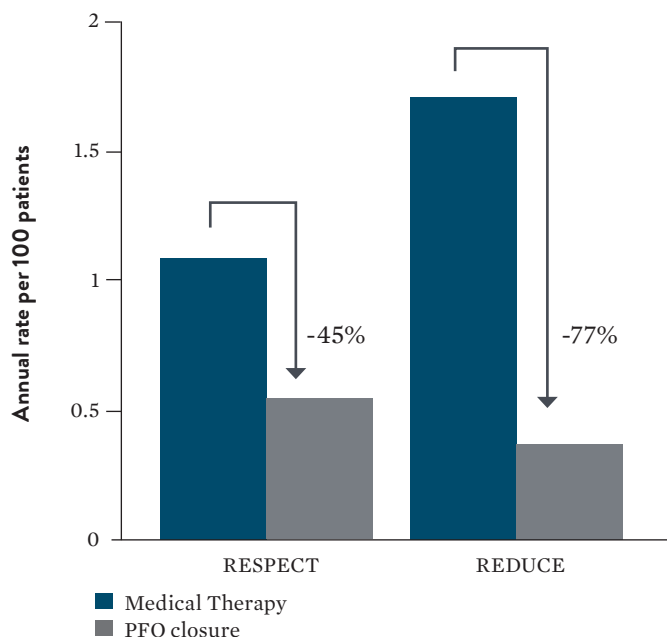
	RESPECT ⁸		REDUCE ⁹		CLOSE ¹⁰	
	PFO	Control	PFO	Control	PFO	Control
SAE rate throughout the follow-up period (%)	40.3	36.0	23.1	27.8	35.7	33.2
	P = 0.17		P = 0.22		P = 0.56	
Procedure-related SAE (%)	2.4		2.5		5.9 (note)	
Device-related SAE n (event per 100 pt-yr rate)	13 (0.4)		6 (0.4*)			
All-Cause Death (%)	1.4	2.3	0.5	0	0	0
	P - value NR		P = 0.55		-	
Serious Atrial fibrillation / flutter % (n, n per 100 pt-yr rate)	1.4% (7, 0.22 per 100 pt-yr)	0.6% (3, 0.11 per 100 pt-yr)	2.3% (10, 0.65 per 100 pt-yr*)	0.4% (1, 0.14 per 100 pt-yr*)	4.6% (NR†)	0.9% (NR†)
Any AF/Flutter % (n, n per 100 pt-yr rate)	4.8% (24, 0.76 per 100 pt-yr)	1.9% (9, 0.34 per 100 pt-yr)	6.6% (29, 1.90 per 100 pt-yr*)	0.4% (1, 0.14 per 100 pt-yr*)	NR	NR
DVT / PE n of patients (%)	20 (4.0)	4 (0.8)	3 (0.7)	2 (0.9)	NR	
Serious bleeding (%)	NR		1.8	2.7	0.8	2.1
			P = 0.57		P = 0.28	

SAE: serious adverse event; DVT: deep-vein thrombosis; PE: pulmonary embolism; NR: not reported
 Note: The CLOSE trial reported procedure- or device-related complications together and did not report patient years.

*Rates calculated based on data in final publication.

†Follow-up patient-years was not reported for CLOSE Trial.

FIGURE 2: COMPARISON OF STROKE RATES ACHIEVED BY PFO CLOSURE VERSUS MEDICAL THERAPY, REPORTED FROM THE RESPECT TRIAL (USING THE AMPLATZER PFO OCCLUDER)⁸ AND THE REDUCE TRIAL (USING GORE OCCLUDERS)⁹.



AMPLATZER PFO Occluder alone (59% reduction)¹¹. Of further note, in an editorial related to this meta-analysis it was estimated that approximately 8 to 11 patients need to be treated to prevent one stroke over a 15 to 20 year time frame¹². This period is considered reasonable, given the relatively young age (~45 years) of patients enrolled in the analyzed trials. The editorial concluded that currently available scientific data support PFO closure combined with medical therapy as a more effective treatment than medical therapy alone.

In the RESPECT trial, PFO closure and medical therapy were associated with similar rates of recurrent stroke of a determined mechanism (0.25 and 0.19 events per 100 patient-years, respectively; p=0.60)⁸. However, recurrent strokes of undetermined mechanism, presumably mediated by a PFO, were significantly less common in patients treated with PFO closure than in patients on medical therapy alone (0.32 vs. 0.86 events per 100 patient-years, respectively; p=0.007; relative risk reduction: 62%). Further analysis suggested that patients with an atrial septal aneurysm and those with a substantial right-to-left shunt might have an even greater relative benefit of PFO closure.

In the CLOSE study¹⁰, with AMPLATZER PFO Occluders being implanted in 51% of the procedures, PFO closure achieved a relative risk reduction for recurrent ischemic stroke of 97%, compared with antiplatelet therapy (no strokes in the PFO closure group vs. 14 in the APT group). This high risk reduction should be interpreted in view of the risk profile of patients enrolled for this trial (i.e. presence of an atrial septal aneurysm or significant shunt). For instance, of the 14 recurrent strokes in the APT group, 9 occurred in the 74 patients with an atrial septal aneurysm.

CONCLUSIONS

- Clinical evidence from 3 recently published randomized controlled trials as well as results from a recent meta-analysis show that PFO closure using the AMPLATZER PFO Occluder or other competitive devices is a generally safe and effective therapy for prevention of recurrent ischemic stroke in patients younger than 60 years who had a stroke of undetermined mechanism.
- Clinical data indicates that the safety of the therapy depends on the type of device, which may be inherent to their design features and materials. In the PFO closure arms of RESPECT and REDUCE, the overall observed rate of AF/Flutter was lower in RESPECT using the AMPLATZER PFO device versus in REDUCE using the GORE devices. In RESPECT, the rate of serious and non-serious atrial fibrillation events beyond the periprocedural period did not differ significantly between the PFO closure group and the medical therapy group.

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INDICATIONS AND IMPORTANT SAFETY INFORMATION

INDICATIONS AND USAGE

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CONTRAINDICATIONS

- Patients with intra-cardiac mass, vegetation, tumor or thrombus at the intended site of implant, or documented evidence of venous thrombus in the vessels through which access to the PFO is gained.
- Patients whose vasculature, through which access to the PFO is gained, is inadequate to accommodate the appropriate sheath size.
- Patients with anatomy in which the AMPLATZER™ PFO device size required would interfere with other intracardiac or intravascular structures, such as valves or pulmonary veins.
- Patients with other source of right-to-left shunts, including an atrial septal defect and/or fenestrated septum.
- Patients with active endocarditis or other untreated infections.

WARNINGS

- Patients who are at increased risk for venous thromboembolic events should be managed with thromboembolic risk reduction regimen after the PFO Closure following standard of care.
- Do not use this device if the sterile package is open or damaged.
- Prepare for situations that require percutaneous or surgical removal of this device. This includes availability of a surgeon.
- Embolized devices must be removed as they may disrupt critical cardiac functions. Do not remove an embolized occluder through intracardiac structures unless the occluder is fully recaptured inside a catheter or sheath.
- Patients who are allergic to nickel can have an allergic reaction to this device.
- This device should be used only by physicians who are trained in standard transcatheter techniques.
- Transient hemodynamic compromise may be encountered during device placement, which may require fluid replacement or other medications as determined by the physician.
- Do not release the device from the delivery cable if the device does not conform to its original configuration, or if the device position is unstable or if the device interferes with any adjacent cardiac structure (such as Superior Vena Cava (SVC), Pulmonary Vein (PV), Mitral Valve (MV), Coronary Sinus (CS), aorta (AO)). If the device interferes with an adjacent cardiac structure, recapture the device and redeploy. If still unsatisfactory, recapture the device and either replace with a new device or refer the patient for alternative treatment.
- Ensure there is sufficient distance from the PFO to the aortic root or SVC (typically defined as 9 mm or greater as measured by echo).

PRECAUTIONS

- The safety and effectiveness of the AMPLATZER™ PFO Occluder has not been established in patients (with):
 - Age less than 18 years or greater than 60 years because enrollment in the pivotal study (the RESPECT trial) was limited to patients 18 to 60 years old
 - A hypercoagulable state including those with a positive test for an anticardiolipin antibody (IgG or IgM), Lupus anticoagulant, beta-2 glycoprotein-1 antibodies, or persistently elevated fasting plasma homocysteine despite medical therapy
 - Unable to take antiplatelet therapy
 - Atherosclerosis or other arteriopathy of the intracranial and extracranial vessels associated with a $\geq 50\%$ luminal stenosis
 - Acute or recent (within 6 months) myocardial infarction or unstable angina
 - Left ventricular aneurysm or akinesis
 - Mitral valve stenosis or severe mitral regurgitation irrespective of etiology
 - Aortic valve stenosis (mean gradient greater than 40 mmHg) or severe aortic valve regurgitation
 - Mitral or aortic valve vegetation or prosthesis
 - Aortic arch plaques protruding greater than 4 mm into the aortic lumen
 - Left ventricular dilated cardiomyopathy with left ventricular ejection fraction (LVEF) less than 35%
 - Chronic, persistent, or paroxysmal atrial fibrillation or atrial flutter
 - Uncontrolled hypertension or uncontrolled diabetes mellitus
 - Diagnosis of lacunar infarct probably due to intrinsic small vessel as qualifying stroke event
 - Arterial dissection as cause of stroke
 - Index stroke of poor outcome (modified Rankin score greater than 3)
 - Pregnancy at the time of implant
 - Multi-organ failure
- Use on or before the last day of the expiration month that is printed on the product packaging label.
- This device was sterilized with ethylene oxide and is for single use only. Do not reuse or re-sterilize this device. Attempts to re-sterilize this device can cause a malfunction, insufficient sterilization, or harm to the patient.
- The AMPLATZER™ PFO Occluder device consists of a nickel-titanium alloy, which is generally considered safe. However, in vitro testing has demonstrated that nickel is released from this device for a minimum of 60 days. Patients who are allergic to nickel may have an allergic reaction to this device, especially those with a history of metal allergies. Certain allergic reactions can be serious; patients should be instructed to notify their physicians immediately if they suspect they are experiencing an allergic reaction such as difficulty breathing or inflammation of the face or throat. Some patients may also develop an allergy to nickel if this device is implanted.
- Store in a dry place.
- Pregnancy – Minimize radiation exposure to the fetus and the mother.
- Nursing mothers – There has been no quantitative assessment for the presence of leachables in breast milk.

ADVERSE EVENTS

Potential adverse events that may occur during or after a procedure using this device may include, but are not limited to:

Air embolus; Allergic drug reaction; Allergic dye reaction; Allergic metal reaction: Nitinol (nickel, titanium), platinum/iridium, stainless steel (chromium, iron, manganese, molybdenum, nickel); Anesthesia reactions; Apnea; Arrhythmia; Bacterial endocarditis; Bleeding; Brachial plexus injury; Cardiac perforation; Cardiac tamponade; Cardiac thrombus; Chest pain; Device embolization; Device erosion; Deep vein thrombosis; Death; Endocarditis; Esophagus injury; Fever; Headache/migraine; Hypertension/hypotension; Myocardial infarction; Pacemaker placement secondary to PFO device closure; Palpitations; Pericardial effusion; Pericardial tamponade; Pericarditis; Peripheral embolism; Pleural effusion; Pulmonary embolism; Reintervention for residual shunt/device removal; Sepsis; Stroke; Transient ischemic attack; Thrombus; Valvular regurgitation; Vascular access site injury; Vessel perforation.

Caution: This product is intended for use by or under the direction of a physician. Prior to use, reference the Instructions for Use provided inside the product carton (when available) or at <https://manuals.sjm.com/> for more detailed information on Indications, Contraindications, Warnings, Precautions and Adverse Events.

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