# One-year clinical experience with the Acorn CorCap™ cardiac support device: results of a limited market release safety study in Italy and Sweden

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*Key words:*
**Cardiac support device; Coronary artery surgery; Heart failure; Mitral regurgitation; Ventricular remodeling.**

*Background.* **The Acorn CorCap™ cardiac support device (CSD) is a mesh-like device intended to provide end-diastolic support and reduce ventricular wall stress. Animal studies with the CorCap™ CSD have demonstrated beneficial reverse remodeling, and preliminary safety studies in patients with heart failure have shown that the device is safe and associated with improved left ventricular (LV) structure and function. The objective of the current study was to further evaluate the safety and efficacy of the CorCap™ CSD in patients with advanced heart failure.**

*Methods.* **Twenty-four patients with dilated cardiomyopathy, severe LV dysfunction, and advanced heart failure (NYHA class II-IV) were enrolled at four centers in Italy and Sweden. All patients underwent CorCap™ CSD implantation either alone (n = 3) or in combination with mitral valve repair/replacement (n = 13), coronary artery bypass surgery (n = 6), combined mitral valve repair/coronary artery bypass surgery (n = 1) or aneurysmectomy (n = 1).**

*Results.* **The LV end-diastolic diameter decreased from 69.3 ± 7.2 to 60.1 ± 9.0 mm at 3 months, 60.9 ± 9.6 mm at 6 months, and 58.9 ± 8.0 mm at 12 months (all $p < 0.05$). A trend toward an improved LV ejection fraction (28.8 ± 10.5% at baseline and 32.4 ± 12.7, 33.1 ± 10.8, and 33.8 ± 13.9% at 3, 6 and 12 months respectively) was also noted. The NYHA functional class, 6-min walking distance, and quality of life as measured using Uniscale were all improved. There were no differences in response among the patients submitted to the different types of concomitant surgery.**

*Conclusions.* **In agreement with earlier safety studies, even the present investigation demonstrated improvements in cardiac structure and function as well as in patient functional status after CorCap™ CSD implantation. Randomized controlled trials are in progress.**

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## Introduction

There have been many important advances in the treatment of patients with heart failure, most notably the introduction of angiotensin-converting enzyme (ACE)-inhibitors and beta-blockers. Both classes of drugs have yielded striking improvements in symptoms and survival that have been demonstrated in many different clinical trials. Indeed, as both drugs have become cornerstones of the therapy for patients with heart failure, they have also firmly established the importance of stimulation of neurohormonal pathways, such as the renin-angiotensin system and the sympathetic nervous system, in the pathophysiology of heart failure[1]. Notwithstanding these advances, it is becoming increasingly clear that heart failure continues to progress in many patients despite optimal medical therapy with neurohormonal antagonists.

Natural history studies have shown that in heart failure progressive left ventricular (LV) remodeling, characterized by LV dilation and a change to a more spherical shape and reduced function, may independently contribute to disease progression[1]. It has been hypothesized that the mechanical burdens associated with LV remodeling may lead to increased wall stress, myocyte stretch and decreased cardiac output and mitral regurgitation, all of which could significantly contribute to disease progression[2]. These observations have also suggested that certain device therapies, by relieving wall stress and myocyte stretch,

might favorably change the natural history of heart failure. Indeed, several innovative approaches have been evaluated to address LV remodeling, including dynamic cardiomyoplasty, partial left ventriculectomy ("Batista procedure"), and endoventricular circular patchplasty (the "Dor procedure")[3,4].

The Acorn CorCap™ cardiac support device (CSD) is a mesh-like implantable device that is surgically implanted around the heart to provide circumferential diastolic support and reduce wall stress and myocyte stretch. Counteracting many of the deleterious changes that occur during the process of LV remodeling has been shown to result in a decreased LV pressure and volume (i.e. reverse remodeling) in three different animal models of heart failure[5-7]. Moreover, in experimental studies, the implantation of the CorCap™ CSD reversed the expression of the fetal gene program, decreased myocyte hypertrophy, improved adrenergic sensitivity, and decreased interstitial fibrosis[8]. Phase I safety studies in patients with advanced heart failure, either alone or in conjunction with mitral valve repair/replacement or coronary artery bypass grafting (CABG), have shown that the CorCap™ CSD is safe and is associated with improvements in ventricular structure and function similar to those that have been observed in preclinical studies[9,10]. These improvements have now been shown to be maintained at 3 years of follow-up[11].

The present study was undertaken to further assess the safety and efficacy of the Acorn CorCap™ CSD in patients with dilated cardiomyopathy and NYHA class II-IV heart failure. Patients have undergone a variety of cardiac procedures concomitant with CorCap™ CSD implantation and this paper reports the 1-year follow-up outcome.

## Methods

**Participating centers.** Three centers from Italy and one from Sweden participated in this study. Each center had preexisting facilities for heart failure patients that included a cardiac surgeon experienced in surgical interventions in patients with reduced LV function and a heart failure cardiologist. Each center followed the same protocol, including patient selection, implant technique, and clinical follow-up. There were 5 patients each from the S. Maria della Misericordia and Niguarda Ca' Granda Hospitals, 4 patients from the San Raffaele Hospital, and 10 patients from the Karolinska Sjukhuset Hospital.

**Patient selection.** Twenty-four patients were enrolled at the four participating centers from June 2001 to June 2003. The major inclusion and exclusion criteria are listed in table I. In general, enrolled patients had idiopathic or ischemic dilated cardiomyopathy with a LV ejection fraction ranging between 10 and 45%, severe LV dilation with a LV end-diastolic diameter ≥ 60 mm and symptoms of NYHA class II, III or IV heart failure. Patients needed to have stable and optimal medical management which included ACE-inhibitors (or angiotensin receptor blockers if ACE-intolerant) and beta-blockers for ≥ 3 months.

The exclusion criteria (Table I) included patients with severe end-stage NYHA class IV heart failure. Patients receiving intravenous inotropes and patients in whom Batista procedures, LV assist devices or heart transplantation were being considered were also excluded. During the initial safety studies, it was determined that it was important to exclude patients with ad-

**Table I.** Patient selection criteria.

| Inclusion criteria | Exclusion criteria |
|---|---|
| Dilated cardiomyopathy | Batista procedure |
| History of NYHA class II/III/IV | Patent CABG |
| LVEF ≥ 10 and ≤ 45% | Primary diastolic dysfunction |
| LVEDD ≥ 60 mm | NYHA class IV dependent on intravenous inotropes/LVAD |
| Acceptable renal, hepatic, and pulmonary function | Acute myocardial infarction |
| Stable and optimal medical management: | ≥ 4 late stage heart failure criteria: |
| ACE-inhibitors or alternate | LVEDD ≥ 80 mm |
| Beta-blockers for ≥ 3 months | Peak $VO_2$ ≤ 13 ml/kg/min |
| | Systolic BP ≤ 80 mmHg |
| | Atrial fibrillation |
| | Heart failure duration ≥ 8 years |
| | Exercise-induced systolic BP increase ≤ 10% |
| | 6-min walk test ≤ 350 m |
| | Blood urea nitrogen ≥ 100 mg/dl |
| | Cachexia |
| | Multiple concomitant surgical procedures |
| | Multiple concomitant surgical procedures and/or previous cardiac surgery |

ACE = angiotensin-converting enzyme; BP = blood pressure; CABG = coronary artery bypass graft; LVAD = left ventricular assist device; LVEDD = left ventricular end-diastolic diameter; LVEF = left ventricular ejection fraction; $VO_2$ = oxygen consumption.

vanced heart failure because of an increased operative risk. A series of 10 late stage heart failure criteria were identified (Table I) and patients with ≥ 4 of these criteria were excluded from the study. Finally, patients with preexisting and patent CABG were excluded because of the implant procedure.

**CorCap™ cardiac support device.** The Acorn CorCap™ CSD (Fig. 1) consists of a mesh-like polyester fabric which is constructed from a multifilamentous yarn to provide high-strength and fatigue-resistant characteristics. The device is designed with bidirectional compliance so that it stretches more in a base to apex direction than in a circumferential direction. This has the effect of reshaping the heart from a sphere to a more ellipsoidal morphology. The knit construction helps to provide a conformal fit so that the CorCap™ CSD lies smoothly on the surface of the heart and reduces abrasion of the epicardium or epicardial coronary vessels. The CorCap™ CSD is available in six sizes, with the final fitting performed by the surgeon.

**CorCap™ cardiac support device implant procedure.** Having performed a sternotomy and opened the pericardium, the LV diameter is measured at the midsegment of the papillary muscles by means of transesophageal echocardiography. The appropriate CorCap™ CSD size is selected by measuring the circumference and base to apex dimensions of the heart using a measuring tape or cord. The CorCap™ CSD is positioned around the ventricles and a series of 4-0 polypropylene sutures are applied to secure the device around the base of the heart. Excess fabric is accumulated anteriorly using a specially designed clamp and a new anterior seam is formed. The final fitting should ensure a "snug" fit in which the CorCap™ CSD fits uniformly around the ventricles without any redundancies. Transesophageal echocardiography measurements are repeated to ensure that the LV end-diastolic diameter has not been reduced by more than 10% with respect to baseline. The snug fit ensures that the CorCap™ CSD relieves mechanical wall stress and stretching in the ventricular wall without adverse reactions related to excessive tightening.

If the CorCap™ CSD implant is the only surgical intervention, it may be implanted without the need for cardiopulmonary bypass. The final fitting of the device when the procedure is performed with other concomitant surgeries, such as mitral valve repair and CABG, is accomplished with the patient off-pump and with a full and beating heart to ensure appropriate fitting.

**Patient follow-up.** Patients were seen for routine follow-up at 3, 6 and 12 months. Routine transthoracic echocardiograms were obtained at each of the follow-up assessments and included measurement of the LV end-diastolic and end-systolic diameters and LV ejection fraction. The patients' quality of life was measured with the Uniscale (visual analogue scale) instrument. The functional status of the patient was assessed by means of the NYHA class and the 6-min walk test.

## Results

**Patient characteristics.** Table II summarizes the baseline characteristics of the 24 patients included in the study. The mean age was 63.7 ± 10.1 years (range 42 to 77 years). While 42% of the patients had ischemic heart disease as the predominant etiology for LV dysfunc-

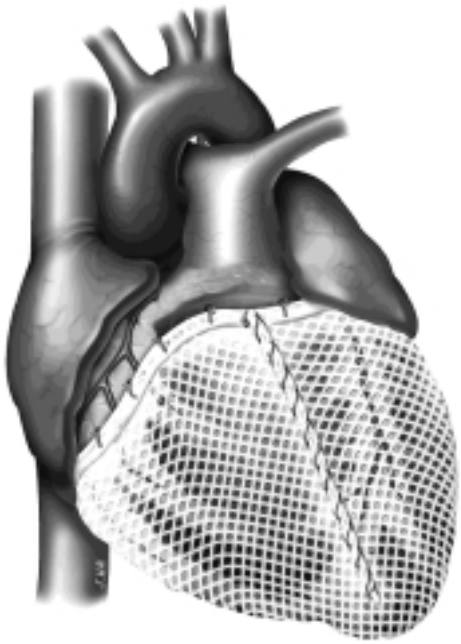

**Figure 1.** *The CorCap™ cardiac support device.*

**Table II.** Baseline characteristics.

| | |
|---|---|
| Age (years) | 63.7 ± 10.1 |
| Etiology | |
| Ischemic | 42% |
| Non-ischemic | 58% |
| NYHA class | 2.8 ± 0.6 |
| LVEDD (mm) | 69.3 ± 7.2 |
| LVEF (%) | 28.8 ± 10.5 |
| Duration of heart failure (years) | 4.6 ± 5.4 |
| Cardiac medications | |
| ACE-inhibitors/ARB | 92% |
| Beta-blockers | 83% |
| Diuretics | 96% |
| Medical history and comorbidities | |
| Atrial arrhythmias | 50% |
| Diabetes | 13% |
| Ventricular fibrillation/cardiac arrest | 8% |
| Pacemaker/AICD | 13% |

ACE = angiotensin-converting enzyme; AICD = automatic implantable cardioverter-defibrillator; ARB = angiotensin receptor blockers; LVEDD = left ventricular end-diastolic diameter; LVEF = left ventricular ejection fraction.

tion, 58% had non-ischemic (idiopathic) cardiomyopathy. The mean NYHA class was 2.8 ± 0.6 and included 8% of patients in NYHA class IV, 59% in NYHA class III, and 33% in NYHA class II. The mean LV end-diastolic diameter was 69.3 ± 7.2 mm and the mean LV ejection fraction was 28.8 ± 10.5%. Background medications at baseline included ACE-inhibitors or angiotensin receptor blockers in 92% of patients, beta-blockers in 83%, and diuretics in 96%. All attempts were made to keep the doses of these background medications constant during follow-up.

Three patients underwent implantation of the CorCap™ CSD as their sole surgical procedure. Among the remaining 21 patients, 13 had a concomitant mitral valve repair or replacement for mitral regurgitation (0-4 scale of severity), 6 patients had concomitant coronary artery bypass surgery (1 to 3 grafts), 1 patient had a mitral valve repair and CABG, and 1 patient had concomitant aneurysmectomy. All 24 patients tolerated the implant surgery without any intraoperative complications related to device implantation.

**Changes in NYHA functional class.** Figure 2 summarizes the changes in NYHA functional class among the 24 patients at 3, 6, and 12 months of follow-up. Most patients improved by at least one functional class and the improvement was maintained during follow-up. In some patients, the NYHA class deteriorated after an initial improvement but in no patient was the follow-up NYHA class worse than at baseline. Overall, the baseline NYHA class was 2.8 ± 0.6, and was reduced to 2.0 ± 0.6 at 3 months ($p < 0.05$), to 1.9 ± 0.7 at 6 months ($p < 0.05$), and to 1.6 ± 0.5 at 12 months ($p < 0.05$) (Table III).

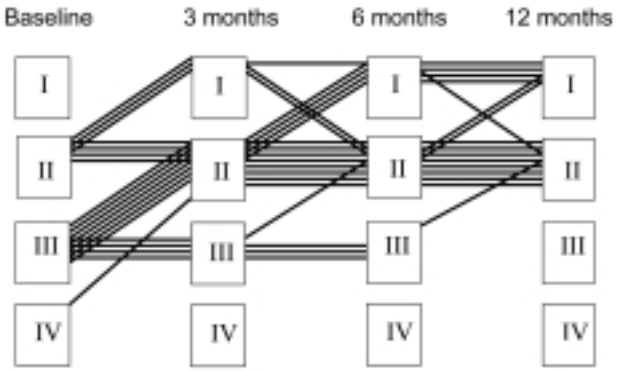


**Figure 2.** *Changes in NYHA functional class. The NYHA class is represented for individual patients, from baseline to 3, 6, and 12 months. Each line represents an individual patient. Most patients improved by at least one functional class and maintained this improvement over time. During follow-up, no patient was in a worse NYHA class with respect to baseline.*

**Changes in left ventricular structure and function.** Table III summarizes the changes in the echocardiographic assessments of LV structure and function. There was a marked decrease in LV size with the mean LV end-diastolic diameter decreasing from 69.3 ± 7.2 mm at baseline to 60.1 ± 9.0 mm at 3 months ($p < 0.05$), 60.9 ± 9.6 mm at 6 months ($p < 0.05$), and 58.9 ± 8.0 mm at 12 months ($p < 0.05$).

The reduction in LV size was associated with a trend toward an increase in LV ejection fraction, although these changes did not reach statistical significance. At baseline, the mean LV ejection fraction was 28.8 ± 10.5%, increasing to 32.4 ± 12.7, 33.1 ± 10.8 and 33.8 ± 13.9% at 3, 6, and 12 months respectively.

The degree of mitral regurgitation, as assessed at color Doppler echocardiography, also improved. Overall, the mean severity of mitral regurgitation decreased from 2.4 ± 1.2 at baseline to 0.6 ± 0.5, 1.0 ± 1.0, and 1.1 ± 0.9 at 3, 6, and 12 months respectively (all $p < 0.05$). As expected, this improvement was most pronounced in the 13 patients who had mitral valve repair or replacement at the time of CorCap™ CSD implantation. In these patients, the severity of mitral regurgitation decreased from 3.1 ± 0.9 at baseline to 0.6 ± 0.5, 1.1 ± 1.2, and 1.0 ± 1.2 at 3, 6, and 12 months respectively (all $p < 0.05$). However, the severity of mitral regurgitation decreased even in the 8 patients who did not have mitral valve surgery (6 patients who had concomitant CABG and 2 patients who had the CorCap™ CSD implant as their only surgical procedure) from 1.4 ± 0.7 at baseline to 0.6 ± 0.5, 0.8 ± 0.4, and 1.2 ± 0.4 at 3, 6, and 12 months respectively. The improvement in the severity of mitral regurgitation in this group could be related to the decrease in LV size and sphericity index.

Figure 3 graphically displays the change in LV end-diastolic diameter over time in all patients (n = 17), in

**Table III.** Results.

| | Baseline (n=24) | 3 months (n=17) | 6 months (n=18) | 12 months (n=16) |
|---|---|---|---|---|
| LVEDD (mm) | 69.3 ± 7.2 | 60.1 ± 9.0* | 60.9 ± 9.6* | 58.9 ± 8.0* |
| LVEF (%) | 28.8 ± 10.5 | 32.4 ± 12.7 | 33.1 ± 10.8 | 33.8 ± 13.9 |
| Mitral regurgitation (0 to 4) | 2.4 ± 1.2* | 0.6 ± 0.5* | 1.0 ± 1.0* | 1.1 ± 0.9* |
| NYHA class | 2.8 ± 0.6 | 2.0 ± 0.6* | 1.9 ± 0.7* | 1.6 ± 0.5* |
| 6-min walk test (m) | 371 ± 105 | 397 ± 84 | 394 ± 126 | 441 ± 105* |
| Uniscale (0-10) | 4.5 ± 2.7 | 6.6 ± 2.5* | 7.7 ± 2.1* | 8.0 ± 1.5* |

LVEDD = left ventricular end-diastolic diameter; LVEF = left ventricular ejection fraction. * $p \leq 0.05$, at t-test and Wilcoxon signed-rank test, mean ± SD.

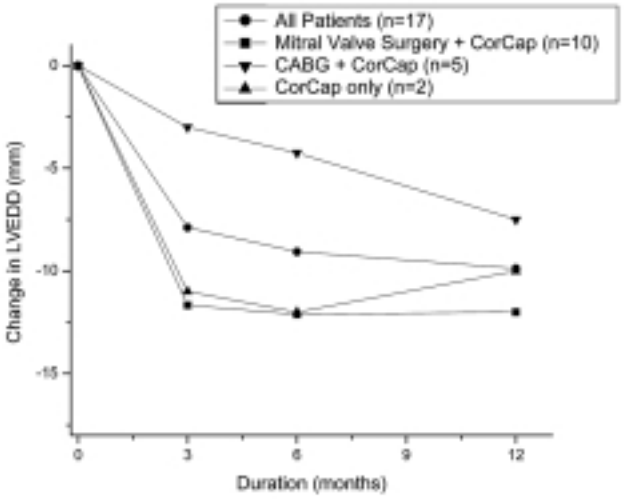


**Figure 3.** *Changes in left ventricular end-diastolic diameter (LVEDD): all patients and subgroups. The LVEDD changes for the study patients are represented at various time points through 12 months of follow-up. All patient subgroups showed a similar pattern of early reduction by 3 months and maintenance of the benefit at 6 and 12 months. There were no significant differences among the subgroups, including patients who had mitral valve repair and CorCap™* (squares), *patients who had coronary artery bypass graft (CABG) and CorCap™* (upturned triangles), *and patients with CorCap™ only* (triangles).

patients who had concomitant mitral valve surgery and CorCap™ CSD implant (n = 10), in patients who had CABG surgery and CorCap™ CSD implant (n = 5), and in patients who had CorCap™ CSD implant only (n = 2). In all groups, the decrease in LV size was detectable as early as 3 months and was reduced further by 6 months. In most groups, the reduction was maximal at 6 months and this benefit was maintained at 12 months. There were no significant differences in the time course or magnitude among the different subgroups although the sample sizes were very small.

**Patient functional improvement.** Table III also summarizes the changes in patient functional assessments. The 6-min walk test increased from a baseline value of 371 ± 105 to 397 ± 84 m at 3 months, 394 ± 126 m at 6 months, and 441 ± 105 m at 12 months ($p < 0.05$). In these patients the quality of life, as assessed using a global assessment Uniscale measure, also improved significantly. At baseline, the quality of life was 4.5 ± 2.7 and improved to 6.6 ± 2.5 at 3 months, 7.7 ± 2.1 at 6 months, and 8.0 ± 1.5 at 12 months (all $p < 0.05$).

**Survival.** Figure 4 shows the Kaplan-Meier survival curve for the 24 patients. Overall, 83% of patients were alive at 2 years. Four patients died during the initial hospitalization due to pneumonia at 21 days (mitral valve repair + CorCap™ CSD), multiorgan failure at 20 days (aneurysmectomy + CorCap™ CSD) and 57 days (CorCap™ CSD only), and gastrointestinal bleeding at 45 days (CABG + CorCap™ CSD). Just as for the original safety study patients, early postoperative deaths were related to the severity of heart failure. Among the 4 patients who died the average number of late stage heart failure criteria at baseline was 2.25. Among the 20 patients who survived the implant and initial hospitalization, the average number of late stage heart failure criteria was only 0.86.

**Major cardiac procedures.** There were 6 patients who required additional cardiac procedures during follow-up. Two patients were implanted with an automatic cardioverter-defibrillator for high-risk ventricular arrhythmias. One patient underwent implant of a biventricular pacemaker at 11 months for persistent signs and symptoms of heart failure. One patient underwent heart transplantation at 6 months because of refractory heart failure. One patient had implantation of a LV assist device 49 days after CorCap™ CSD implant because of hemodynamic deterioration. This patient subsequently died. Finally, 1 patient had to be reoperated 4 times within 19 days of mitral valve repair and CorCap™ CSD implantation. These procedures included re-exploration for postoperative bleeding and sternal debridement for suspected sternal wound infection. This

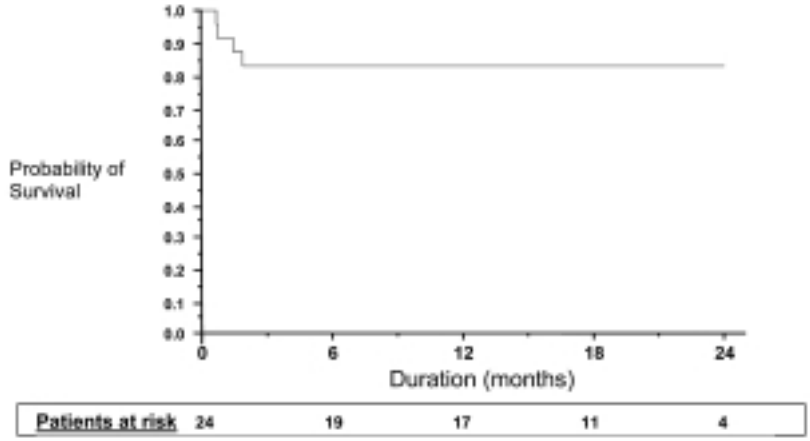


**Figure 4.** *Kaplan-Meier survival curve. The survival curve for the 24 patients enrolled in the limited market release surveillance study is represented. There were 4 early deaths but the overall survival at 2 years was 83%. The* box *contains the number of patients at risk at each time point.*

patient had a clinical picture of sepsis of uncertain origin that did not improve after sternal debridement. He subsequently was submitted to re-exploration and removal of the CorCap™ CSD. When the sepsis picture did not change, he was again operated upon and the mitral valve ring and annuloplasty were removed. Despite this very complex surgical course, this patient is still doing well at 12 months.

**Hospitalizations.** The patients in this study tended to be hospitalized less frequently after CorCap™ CSD implantation. During the year prior to implant, these patients were each hospitalized on an average of 1.5 ± 1.1 occasions. The average number of days per hospitalization was 11.7 ± 13.5 with 0.7 ± 1.3 days in the intensive care unit. During the year following implant, there was an average of 0.6 ± 0.7 hospitalizations per patient. Each hospitalization averaged only 6.3 ± 14.0 days without any days spent in the intensive care unit. Although these data are not controlled and are retrospective, they are consistent with reduced resource utilization after CorCap™ CSD implantation.

## Discussion

One of the important hallmarks of the clinical syndrome of heart failure is ventricular remodeling, characterized by progressive ventricular enlargement and a change to a more spherical shape and reduced LV function. It is well known that medical therapy, including ACE-inhibitors and beta-blockers, may attenuate many of these changes. However, because ventricular remodeling may continue despite drug therapy, research for innovative therapies which can act on non-receptor-mediated pathways, such as increased wall stress and myocyte stretch, has been widespread. The current interest in a variety of device interventions, such as the Acorn CorCap™ CSD, is based on the hypothesis that relief of wall stress and myocyte stretch could yield important benefits in heart failure.

Proof of concept studies for the Acorn CorCap™ CSD have been completed in three independent models of heart failure, including a microembolic model in dogs, high-rate pacing in sheep and acute myocardial infarction in sheep[5-7]. All three models have shown similar benefit, including a reduced LV size and improved cardiac function, which are consistent with reversal of the process of ventricular remodeling. For example, in a dog model of heart failure produced by repeated administration of intracoronary microemboli, the LV end-diastolic volume decreased from 68 ± 4 ml at baseline to 61 ± 4 ml at 3 months ($p < 0.005$) while the control group had a progressive increase in LV volume from 67 ± 5 to 83 ± 8 ml[5]. LV ejection fraction increased from 34 ± 1 to 41.1 ± 1% at 3 months ($p < 0.005$) in the CorCap™ CSD-treated group but decreased from 36 ± 1 to 28 ± 2% in the control group. Other mechanistic studies have shown that the CorCap™ CSD improves the histomorphologic characteristics (less myocyte hypertrophy, less interstitial fibrosis, greater capillary density) and isolated myocyte function (increased percent shortening), and decreases the heart failure-stimulated fetal gene and stretch protein levels (p21ras, c-fos, and p38 α/β mitogen-activated protein kinases) and apoptosis[5-8]. Overall, this large pre-clinical experimental database has provided firm evidence that in heart failure relief of wall stress could have important benefits.

An early safety study experience including 48 patients submitted to CorCap™ CSD implantation either alone or in association with a variety of procedures such as mitral valve repair and CABG, yielded encouraging preliminary results[9-11]. During a 12-month follow-up, the patients were found to have had a reduction in LV end-diastolic diameter from 72.8 ± 7.1 to 64.1 ± 10.6 mm ($p < 0.05$) and an increase in LV ejection fraction from 23.6 ± 8.0 to 29.9 ± 12.2% ($p < 0.05$). These beneficial effects were still present at 3 years of follow-up[11].

Furthermore, in the initial safety studies, there were improvements in both the NYHA functional class and quality of life, as assessed using the Minnesota Living with Heart Failure Questionnaire (a heart failure specific instrument)[9-11]. These improvements were also evident in the 12 patients who underwent CorCap™ CSD implantation as their sole surgical procedure. Importantly, most of the safety study patients were treated with a background medication regimen that included beta-blockers and ACE-inhibitors. For this reason, it may be safely presumed that indeed the observed changes were additive to the improvements attributable to an optimal medical regimen.

The present study provides confirmatory evidence, in a separate group of patients from two different countries, of the positive outcome observed for the original safety study patients. Thus, implantation of the CorCap™ CSD, in addition to a variety of other cardiac procedures, was associated with a reduced LV size, a trend toward an improvement in ejection fraction and improvements in patient functional status as reflected by improvements in the NYHA class and quality of life. The overall survival in this patient cohort was 83% at 2 years, which is quite remarkable considering the advanced state of heart failure at baseline. All these changes are consistent with reverse remodeling of the ventricle and with an improved patient functional status.

The limited size of the current study did not allow a detailed mortality assessment, although several observations may still be made. As was demonstrated in the previous safety study, and as is generally held for advanced heart failure patients, even the patients in the current study had a high surgical risk, with 4 deaths occurring early after surgery. In addition, several major cardiac procedures were performed. Despite this, no

late deaths were recorded, with an 83% overall survival at 2 years of follow-up.

One important limitation of the present study is that patients underwent a variety of concomitant surgical procedures (mitral valve repair/replacement in 13, CABG in 6, mitral valve replacement and CABG in 1 and aneurysmectomy in 1) so that it is not possible to determine whether the observed changes are due to the CorCap™ CSD, the concomitant surgical procedure or both. Besides, no information on CABG patency was available. Nonetheless, the observed changes are very consistent with those of previous reports in patients with concomitant surgery as well as patients receiving only the CorCap™ CSD. Currently, two prospective randomized and controlled multicenter trials are ongoing in North America and Europe and have enrolled 300 and 100 patients respectively[12]. These trials will provide a formal assessment of the effects of the CorCap™ CSD either alone or in combination with other cardiac surgery procedures since they will include a control group which does not receive the CorCap™ CSD for a direct comparison.

One common concern about the potential use of the CorCap™ CSD in patients with heart failure is the possible development of a constrictive pattern due to fibrosis of the device around the heart. Extensive histomorphologic analysis in both dogs and sheep has shown that indeed there is a thin layer of fibrous encapsulation, which however does not progress over time[5]. Pressure volume loops showed an improvement in the end-systolic pressure volume relationship, consistent with an improved systolic performance, without any changes in the end-diastolic pressure volume relationship. Kleber et al.[13] also studied a subset of 10 patients by means of detailed hemodynamic evaluation and pressure valve loops. These patients demonstrated an improved systolic pressure without any evidence of constriction. Although these parameters were not specifically addressed in the current study, there were no clinical or echocardiographic signs of constriction in any patient; on the other hand, no specific histological evaluations were carried out on accessible specimens (i.e., patients who died and/or who underwent reoperation, regardless of the etiology). Therefore, comprehensive echocardiographic analysis of cardiac filling and constrictive physiology is being assessed prospectively in both of the ongoing clinical trials[12].

There have been several interventions designed to mitigate the effects of mitral regurgitation in patients with dilated cardiomyopathy[14]. Of note, there are multiple mechanisms contributing to mitral insufficiency in patients with this disease including a dilated annulus, a dilated left atrium, and an increased tethering distance for the papillary muscles. It is of interest that in the current study patients who did not have interventions on their mitral valve also had less severe mitral insufficiency. This may be due to the reduction in LV size and to the more ellipsoidal shape induced by the CorCap™ CSD.

In summary, this multicenter study including 24 patients who underwent CorCap™ CSD implantation with a variety of concomitant surgical procedures demonstrated important improvements in LV structure and function as well as patient functional status. These encouraging results confirm the results of an earlier safety study. The results of two randomized controlled trials will provide a formal assessment of the safety and efficacy of the CorCap™ CSD.

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