# Mitral durability after robotic mitral valve repair: Analysis of 200 consecutive mitral regurgitation repairs

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**Objectives:** The study objective was to review a single-center experience on robotic mitral valve repair to treat mitral regurgitation, with a specific focus on midterm echocardiographic mitral durability. No data assessing the quality or durability of repaired mitral valves are currently available.

**Methods:** A total of 200 patients who underwent robotic mitral regurgitation repair using the da Vinci system (Intuitive Surgical, Inc, Sunnyvale, Calif) between August 2007 and December 2012 were evaluated. Serial echocardiographic results and operative and procedural times were analyzed.

**Results:** Mitral regurgitation repairs were successfully performed, and no or mild residual mitral regurgitation developed in 98.0% of patients, with no conversion to sternotomy. No in-hospital deaths occurred. Follow-up was completed in 96.5% of patients with a median of 31.4 months (interquartile range, 12.4-42.3 months). During follow-up, 4 late deaths, 2 strokes, 1 low cardiac output, 1 newly required dialysis, and 1 reoperation for mitral regurgitation occurred. Freedom from major adverse cardiac events at 5 years was 87.7% ± 5.1%. Regular echocardiographic follow-up (>6 months) was achieved in 187 patients (93.5%). At a median of 29.6 months (interquartile range, 14.9-45.8 months), 21 patients (10.5%) demonstrated moderate or greater mitral regurgitation. Freedom from moderate or greater mitral regurgitation at 5 years was 87.0% ± 2.6%. Mean cardiopulmonary bypass and crossclamping times were 182.9 ± 48.4 minutes and 110.9 ± 34.1 minutes, respectively, demonstrating a significant decrease in both times according to the chronologic date of surgery.

**Conclusions:** Robotic mitral regurgitation repair is technically feasible and efficacious, demonstrating favorable midterm mitral durability and improved procedural times as experience increases. (J Thorac Cardiovasc Surg 2014;148:2773-9)

Robotic mitral valve (MV) repair is a proven and acceptable approach for treating complex MV diseases, especially in centers experienced with minimally invasive cardiac surgery (MICS) techniques and the da Vinci surgical system (Intuitive Surgical, Inc, Sunnyvale, Calif).[1,2] Studies report excellent early outcomes after robotic MV repair, and the full anatomic correction of the mitral leaflet and annulus using minithoracotomy incision and robotic assistance is a safe and effective approach for all types of degenerative MV pathology.[3-6]

As for the validity of MV repair using MICS, it still needs to be clearly demonstrated that the procedure provides complete surgical correction. To do so, the long-term durability of repaired MV function should be addressed first. However, limited data are available on the long-term efficacy of MV repair using the robotic approach. Although there are several reports on postoperative mortality/morbidity and long-term freedom from mitral reoperation (ie, repair or replacement), data on the long-term echocardiographic outcomes of MV repair are scarce. Of the published studies on the surgical outcomes of robotic MV repair, only a few include intermediate to long-term echocardiographic follow-up examinations[3,4,7,8]; however, even those studies only report the last echocardiographic results, and only 1 study reported 5-year Kaplan–Meier freedom from reoperation.[4] In this regard, no study reports the long-term quality of the repaired MVs (eg, regurgitation or stenosis) or freedom from significant mitral regurgitation (MR) recurrence according to results obtained using long-term regular echocardiographic follow-up. Thus, we assessed in the current study our experience of robotic MV repairs, with a specific focus on the midterm echocardiographic outcomes of repaired MVs.

## METHODS

### Patients

Between August 2007 and December 2012, 369 MICS procedures were performed at the Asan Medical Center using the da Vinci surgical system. Of these, 209 patients underwent MV repair. After excluding patients whose MV pathology was diagnosed as mitral stenosis, a total of 200 consecutive patients who had MV repair for MR with or without

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**Abbreviations and Acronyms**

ACC = aortic crossclamping
AF = atrial fibrillation
CPB = cardiopulmonary bypass
IQR = interquartile range
MICS = minimally invasive cardiac surgery
MR = mitral regurgitation
MV = mitral valve
TAP = tricuspid annuloplasty
TEE = transesophageal echocardiography

concomitant tricuspid annuloplasty (TAP) or atrial fibrillation (AF) ablation were identified. The exclusion criteria for robotic MV repair included patients who required an additional cardiac procedure (eg, aortic valve surgery, coronary artery bypass grafting) and patients with risk factors that could affect the MICS approach (eg, peripheral arterial obstructive disease, severely tortuous abdominal aorta, severe cardiomegaly, and difficult chest wall shape for port-access surgery). Robotic MV repairs were performed by a single console surgeon (J.W.L.), along with 5 bedside surgeons. The choice of robot-assisted cardiac surgery primarily depended on the condition of the patient and preferences decided after providing informed consent. We retrospectively reviewed preoperative characteristics, early and late clinical outcomes, and echocardiographic results.

This study was approved by the Asan Medical Center Ethics Committee/Review Board, which waived the requirement for informed patient consent because of the retrospective nature of the analysis.

## Operative Technique

Conventional general anesthesia with dual-lumen endotracheal intubation and single left-lung ventilation was used in all patients. A transesophageal echocardiography (TEE) probe was inserted after intubation, and external defibrillator patches were attached to the back. After percutaneous superior vena caval cannulation through the right internal jugular vein, patients were placed in the supine position with the right chest elevated approximately 30°. Cardiopulmonary bypass (CPB) was established by cannulating the femoral artery and vein. If atherosclerotic burden was identified anywhere in the aortic arch or descending thoracic or abdominal aorta on preoperative computed tomography imaging, an alternative aortic cannulation technique was used (eg, axillary or direct transthoracic ascending aortic cannulation). A 4-cm minithoracotomy horizontal incision was made in the fourth intercostal space in the mid-axillary line, and a dynamic left atrial retractor was placed in the mid-clavicular line. The left arm of the robot was inserted through the third intercostal space in the anterior-axillary line, and the right arm was inserted through the sixth intercostal space in the mid-axillary line. A Chitwood transthoracic aortic clamp (Scanlan International Inc, St Paul, Minn) was placed posterior to the mid-axillary line in the third intercostal space. The chest cavity was flooded with carbon dioxide to mitigate intracavitary air. Femoral cannulation was performed through a 2-cm oblique infrainguinal incision with anterior exposure of the femoral vessels. Vacuum-assisted venous drainage was used during CPB, and myocardial protection was achieved using antegrade cold crystalloid cardioplegic solution (Custodiol HTK; Köhler Chemie GmbH, Bensheim, Germany). After cardioplegic arrest and aortic crossclamping (ACC), the MV was exposed through the interatrial groove. Standard mitral repair techniques were used.

Among patients who required right atriotomy for concomitant TAP or AF ablation procedures, the superior vena cavae were snared using Bulldog clamps. Concomitant TAPs were conducted in 26 patients (13.0%), and concomitant maze procedures were performed in 44 patients (22.0%) in whom the modified Cox-maze III procedure with argon-based cryothermy (Cardioblate CryoFlex Surgical Ablation Probe; Medtronic, Inc, Minneapolis, Minn) was performed. Details regarding our modified AF ablation lesion set were previously described.[9]

## Echocardiographic Evaluation

All patients underwent 2-dimensional echocardiographic analysis and Doppler color-flow imaging using HP Sonos 5500 (Hewlett-Packard, Andover, Mass), Philips iE33 (Philips Medical Systems, Bothell, Wash), and GE vivid 7, E9 (GE Medical System, Horten, Norway) in the 2 months leading up to surgery. Preoperative TEE was also performed to more accurately analyze MV morphology. Immediate postoperative TEE was confirmed by a cardiologist in the operating room after the patient was weaned from CPB, and all patients underwent transthoracic echocardiography before discharge. MR was detected and semiquantitatively graded as mild, moderate, or severe, using color Doppler flow imaging.[10]

## Follow-up

Data were obtained until November 2013, through biannual visits to the outpatient clinic. Early mortality was defined as death within 30 days of surgery. Data on vital status, date of death, and causes of death were obtained from the Korean national registry of vital statistics. Major adverse cardiac and cerebrovascular events were defined as all-cause death or valve-related complications, the latter of which included thromboembolism, reoperation, infective endocarditis, and warfarin-related hemorrhage. Serial echocardiographic follow-up examinations were performed to detect MR recurrence. Recurrent MR was defined as moderate or greater MR (ie, proximal isovelocity surface area radius >0.4 cm).

## Statistical Analysis

Categoric variables are presented as frequencies and percentages. Continuous variables are expressed as the means ± standard deviations or medians with ranges. The cumulative incidence rates of major event-free survival and freedom from MR were estimated using the Kaplan–Meier method. To assess learning period effects, CPB, ACC, and operative times (skin-to-skin) were reviewed on the basis of the chronologic date of surgery and analyzed using bivariate correlation analysis. All reported *P* values are 2-sided. All statistical analyses were performed using SPSS, version 18.0 (IBM, Armonk, NY).

# RESULTS

## Baseline Characteristics and Operative Data

The preoperative patient characteristics are listed in Table 1. Median age was 47 years (interquartile range [IQR], 36-57 years), and 26.5% of patients were classified with New York Heart Association functional class III/IV. Preoperative MR grade was moderate-to-severe in 17 patients (8.5%) and severe in 183 patients (91.5%). Two patients underwent prior cardiac surgeries via sternotomy; 1 patient received ventricular septal defect closure, and 1 patient underwent MV repair. In both cases, we used transthoracic clamps with routine antegrade cardioplegic infusion via root cannulation.

Robotic MR repairs were successfully performed in 100% of patients with no, trivial, or mild residual MR (proximal isovelocity surface area radius ≤0.4 cm) noted on intraoperative TEE (confirmed by the cardiologist) after weaning off CPB without intraoperative conversion to