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Transapical Beating-Heart Mitral Valve Repair with NeoChord DS1000 Implantation: A Single-Center Retrospective Experience

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Original Article

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Keywords: mitral regurgitation · transapical repair · NeoChord · neochordae · minimally invasive surgery

Abstract

Objective: To evaluate early and mid-term outcomes of transapical beating-heart mitral valve repair with the NeoChord DS1000 system, using time-to-event analysis to assess freedom from recurrent mitral regurgitation in a single-center cohort.

Methods: We retrospectively reviewed 31 consecutive patients with severe degenerative mitral regurgitation who underwent NeoChord DS1000 implantation between 2016 and 2022. Freedom from moderate-or-greater (≥ grade 2) recurrent regurgitation was estimated by Kaplan-Meier analysis, and outcomes were compared between the first 16 and last 15 procedures to evaluate the learning curve.

Results: Mean age was 57.1 ± 14.0 years (87.1% male); 71.0% had a low surgical risk profile (EuroSCORE II < 2). All patients had severe (grade 3–4) MR, predominantly of the P2 segment (90.0%). Procedural success was 100%, with a mean operative time of 122.2 ± 14.3 minutes. There was no intraoperative or 30-day mortality; new-onset atrial fibrillation occurred in 9.7% of cases. At discharge, 96.8% achieved MR ≤ grade 1. Kaplan-Meier analysis showed freedom from

moderate-or-greater (≥ grade 2) MR of 93.5% at 3 months, 77.4% at 1 year, and 66.9% at 2 years; one patient (3.2%) required reoperation for chordal rupture. Durability trended better in the later half of the series.

Conclusions: Transapical NeoChord DS1000 repair provides excellent early safety and favorable perioperative outcomes in well-selected patients, but time-to-event analysis shows that mid-term durability is more limited than cross-sectional reporting suggests, underscoring the need for strict anatomical screening, structured surgical experience, and continued echocardiographic surveillance.

Introduction

Severe degenerative mitral regurgitation (MR) remains a leading clinical challenge across Western populations, representing the second most common valvular pathology in Europe [1, 2]. Practice guidelines from the ESC/EACTS and ACC/AHA advocate surgical intervention for symptomatic severe primary MR, as well as for asymptomatic cases demonstrating left ventricular decompensation, pulmonary hypertension, or new-onset atrial fibrillation [3, 4, 5]. Reconstructive surgery adhering to the "respect rather than resect" doctrine is universally favored over valve replacement, as it maintains subvalvular apparatus integrity, optimizes ventricular mechanics, and obviates prosthesis-related complications [6].

Within the spectrum of leaflet-preservation options, off-pump transapical repair using the NeoChord DS1000 system offers a distinct physiological advantage. By obviating cardiopulmonary bypass and aortic cross-clamping, this approach enables dynamic, real-time verification of valve competence on the beating heart under three-dimensional transesophageal echocardiography (3D TEE) guidance [7]. Since the initial proof-of-concept in the TACT trial [8], accumulating evidence across multiple clinical series has established its procedural safety, feasibility, and early effectiveness [9, 10, 11, 12, 13, 14].

Despite encouraging early reports from multicenter data [9–14], available evidence suffers from two key limitations. First, most series report mid-term durability using cross-sectional evaluations at fixed intervals rather than proper time-to-event methodology. Second, detailed information on anatomical selection algorithms and quantitative learning curves remain insufficient, particularly from non-Western European centers. Addressing these gaps, we present our institutional

experience with a consecutive Turkish cohort. Our study has three main objectives: to define strict anatomical candidacy criteria, to evaluate freedom from recurrent MR via Kaplan-Meier survival estimates, and to examine the impact of the surgical learning curve on procedural durability.

In this study, we present the clinical, operative, and serial echocardiographic outcomes of 31 consecutive patients who underwent transapical NeoChord DS1000 repair at our center between 2016 and 2022.

Methods

Study population and ethics

From November 2016 to June 2022, 31 consecutive patients with severe degenerative MR undergoing NeoChord DS1000 repair were evaluated at Gülhane Training and Research Hospital [3, 4]. All patients fulfilled standard ACC/AHA and ESC/EACTS criteria for surgical intervention [3, 4]. Anatomical inclusion required isolated or multi-segment posterior leaflet prolapse/flail (P1–P3), or bileaflet involvement. On the other hand, significant mitral annular dilatation and leaflet or annular calcification were treated as absolute exclusion criteria, as ringless chordal-only repair yields suboptimal durability in these cohorts [30]. Patients with anatomy unsuitable for NeoChord repair—such as marked annular dilatation, calcification, or complex bileaflet pathology—were directed to robotic mitral valve surgery, our institutional standard for non-sternotomy approaches [27]. Transcatheter edge-to-edge repair (M-TEER) was not performed during this period, as it lacked coverage under the Turkish Social Security Institution (SGK/SUT) reimbursement framework. Mitral regurgitation severity was recorded using a standard 0 to 4 numerical scale (0: none/trace, 1: mild, 2: moderate, 3: moderate-to-severe, 4: severe) to ensure objective consistency across all echocardiographic evaluations. The study protocol was approved by the local Institutional Ethics Committee (Gülhane Scientific Research Ethics Committee, decision no: 2022/269, dated September 12, 2022). Clinical, surgical, and serial echocardiographic data—collected at baseline, discharge, 1, 3, and 6 months, 1 year, and mid-term follow-up—were retrieved from institutional electronic medical records and archives.

Device

The NeoChord DS1000 system (NeoChord, Inc., Eden Prairie, MN, USA) is a specialized delivery tool designed for transapical, off-pump placement of expanded polytetrafluoroethylene (ePTFE;

CV-4 Gore-Tex) artificial chordae on a beating heart [15]. The system carries CE mark certification in Europe and is currently under evaluation versus conventional surgical repair in the prospective randomized ReChord trial (NCT02803957) [16].

Surgical technique

Surgical procedures were conducted under general anesthesia with double-lumen endotracheal intubation for single right-lung ventilation. Access was gained via a left anterolateral mini-thoracotomy through the fourth or fifth intercostal space. Following pericardial exposure, the left ventricular entry point was identified 2–3 cm posterolateral to the apex under continuous 2D/3D TEE visualization. Two concentric 2-0 polypropylene purse-string sutures with Teflon pledgets were placed for apical control, and systemic heparinization (100 U/kg) was initiated to achieve an activated clotting time > 300 seconds. Following transapical ventriculotomy, the NeoChord DS1000 device was inserted and guided into the left atrium, carefully navigating clear of native chordal structures. Under real-time 3D TEE visualization, the prolapsed leaflet segment was captured, with secure tissue contact confirmed by the illumination of all four device fiber-optic indicators. An ePTFE suture was then deployed through the free leaflet edge and pulled through the apex. Suture tension was adjusted dynamically on the beating heart to restore coaptation. This sequence was repeated until adequate chordal support was achieved. Valve competence and MR reduction were verified by TEE prior to anchoring the neochords to the ventricular apex over Teflon pledgets. In our practice, this pledgeted apical fixation achieved reliable hemostasis at the ventriculotomy site without requiring secondary bleeding-control measures. Finally, heparin was neutralized with protamine sulfate, a single chest tube was inserted, and the mini-thoracotomy was closed in standard anatomical layers. Operational steps are demonstrated in Supplementary Video 1.

Statistical analysis

Continuous parameters are reported as mean ± standard deviation along with range, while categorical variables are summarized using frequencies and percentages. Freedom from moderate-or-greater (≥ grade 2) recurrent MR was calculated via Kaplan-Meier time-to-event analysis. An event was defined as the primary echocardiographic confirmation of ≥ grade 2 MR during serial follow-up (discharge, 1, 3, 6 months, 1 year, and mid-term). Patients remaining event-free were censored at their most recent echocardiographic evaluation. To evaluate the institutional learning

curve, freedom from recurrence was compared between the early (n=16) and late (n=15) halves of the surgical experience. Statistical computations were conducted using SPSS software (SPSS Inc., Chicago, IL, USA).

Results

The final study cohort comprised 31 patients (27 men, 4 women; mean age 57.1 ± 14.0 years; range 31–83 years). Overall, 71.0% of the cohort demonstrated a low surgical risk profile with EuroSCORE II < 2. Severe baseline MR (grade 3 or 4) was documented in all patients. Pathological involvement predominantly affected the P2 segment (90.0%), and 77.4% were categorized as anatomical Type A (isolated central posterior leaflet prolapse). Baseline clinical features and preoperative echocardiographic parameters are detailed in Tables 1 and 2.

Surgical intervention was driven by symptoms (NYHA class ≥ II) in 27 patients (87.1%), while 4 patients (12.9%) were asymptomatic at baseline (NYHA class I). Among the asymptomatic group, elevated pulmonary artery systolic pressure (58 mmHg) served as the objective surgical trigger in one patient (25.0%). The remaining three asymptomatic patients underwent surgery based on isolated P2 flail anatomy, low operative risk, high expected repair durability, and shared patient decision-making.

Mean operative duration was 122.2 ± 14.3 minutes. Implanted neochords ranged from 2 to 7 per patient, with 4 chords being the most frequent (48.3%). Procedures were completed without intraoperative complications, sternotomy conversions, or mechanical circulatory support (IABP or ECMO). Autologous cell salvage was utilized in 19 patients (61.3%; mean volume 631 ± 298 mL), and 5 patients (16.1%) received fresh frozen plasma (mean 380 ± 161 mL); notably, no allogeneic packed red blood cells were transfused. Early postoperative metrics reflected rapid recovery: mechanical ventilation averaged 3.3 ± 1.8 hours, chest drainage was 220 ± 138 mL, and ICU length of stay was 16.9 ± 4.0 hours, with 93.5% of patients discharged from the ICU within 24 hours. Overall hospital stay averaged 6.0 ± 2.1 days. Intraoperative and 30-day mortality was zero. Postoperative new-onset atrial fibrillation developed in 9.7% of cases as the sole recorded complication. Comprehensive perioperative findings are provided in Table 3.

At discharge, 96.8% of patients achieved successful MR reduction (≤ grade 1). One patient (3.2%) discharged with grade 2 MR was lost to follow-up despite repeated outreach attempts. Within the

first postoperative year, one patient developed grade 3 MR secondary to neochord rupture and underwent reoperation at another institution. Serial echocardiographic findings for 30 patients at 3 months and 1 year, and 29 patients at mid-term follow-up (up to 4 years), are summarized in Table 4. At 1-year evaluation, cross-sectional freedom from moderate-or-greater MR (≥ grade 2) was 80.0% (24/30; grade 2 MR in 16.7%, grade 3 MR in 3.3%). At the last available follow-up, cross-sectional MR freedom was 62.1% (18/29). Over the mid-term period, one additional patient presented with asymptomatic grade 3 MR and was managed conservatively. Extended surveillance identified two patients with sustained grade 1 MR at 5.5 and 6 years.

To account for the precise timing of recurrent regurgitation, freedom from ≥ grade 2 MR was further evaluated using Kaplan-Meier survival estimates. This time-to-event model included the patient lost to follow-up after discharge as an early event. Estimated freedom from recurrent moderate-or-greater MR was 96.8% at discharge, 93.5% at 3 months, 90.3% at 6 months, 77.4% at 1 year, and 66.9% at 2 years. Beyond 2 years, the pool of patients at risk dropped considerably (n=7 at 3.5 years and n=6 at 4 years), constraining the statistical precision of extended-term projections (Table 5, Figure 1).

To evaluate institutional experience, cases were chronologically divided into an early cohort (first 16 patients) and a late cohort (subsequent 15 patients). Cumulative freedom from ≥ grade 2 MR at 1 and 2 years increased from 75.0% and 61.4% in the early group to 80.0% and 72.7% in the late group. This trend demonstrates a progressive improvement in procedural durability alongside surgical familiarity.

Discussion

Transapical beating-heart repair using the NeoChord DS1000 system bridges conventional leaflet-preserving surgical concepts with an off-pump, minimally invasive platform. Beyond the reach of certain transcatheter options, this technology accommodates a broader anatomical spectrum while allowing real-time, dynamic echo verification of valve competence under 3D TEE guidance [7]. Early procedural safety and feasibility—first demonstrated in the benchmark TACT trial [8] have been consistently validated across several multicenter series [9–14]. Notably, propensity-matched evidence from D'Onofrio et al. confirmed that early mortality and complication rates with NeoChord repair are fully comparable to conventional open surgery [17].

The baseline demographics of our cohort—characterized by male predominance (87.1%), a mean age of 57.1 years, preserved LVEF, and low operative risk—align closely with international registries [9, 12]. For instance, a systematic review by Ahmed et al. comprising 249 patients similarly noted a male-dominant population (70%) with a wide age distribution (44–84 years) [9]. Crucially, 77.4% of our patients presented with isolated central P2 prolapse (Type A anatomy). This high proportion underscores our adherence to optimal candidacy criteria, as NeoChord repair achieves its most predictable durability in localized posterior leaflet pathology.

Our perioperative results reinforce the established safety profile of the NeoChord platform. Mean operative duration (122 minutes) and chordal deployment numbers (2–7 neochords) match broad multicenter experience [9, 12]. Notably, zero intraoperative complications, sternotomy conversions, or perioperative deaths reflect the high procedural safety documented across experienced centers [9, 17]. Postoperative new-onset atrial fibrillation occurred in 9.7% of cases, positioning well within reported international benchmarks (6%–50%) [17, 18, 19]. Recovery metrics were equally encouraging: mean ICU length of stay (<17 hours) and overall hospitalization (6 days) compare advantageously to reported benchmark series, such as D'Onofrio et al. (1 day ICU, 7 days hospital) [17]. Furthermore, the complete avoidance of allogeneic red blood cell transfusions (61.3% autologous cell salvage utilization) highlights the blood-sparing benefit inherent to this off-pump approach.

Longitudinal repair durability remains the primary benchmark for evaluating transapical chordal procedures. Cross-sectional evaluation revealed that 80.0% of patients maintained freedom from moderate-or-greater MR at 1 year, stabilizing at 62.1% at the final mid-term assessment (up to 4 years). To capture the precise temporal distribution of recurrent regurgitation, time-to-event Kaplan-Meier modeling was applied, demonstrating cumulative MR freedom rates of 93.5% at 3 months, 77.4% at 1 year, and 66.9% at 2 years. The progressive attrition in the number of patients at risk beyond the 2-year mark naturally limits definitive statistical projections for extended follow-up periods. The lower rates observed with Kaplan-Meier estimation compared to cross-sectional proportions highlight that certain MR recurrences surfaced during intermediate follow-up intervals, a distinction captured only through longitudinal time-to-event modeling. Reporting both metrics is therefore essential for rigorous cross-study comparisons. In a large multicenter cohort of 203 patients, Gerosa et al. reported cross-sectional MR freedom (≥ grade 2) rates of 87%,

74%, and 64% at discharge, 1 year, and mid-term, respectively [12]. While our cross-sectional outcomes remain largely comparable, our lower Kaplan-Meier curve reflects sample size constraints, rigorous time-dependent event logging, and the strict accounting of an early technical failure (grade 2 MR at discharge) as an immediate event. In their landmark study, Colli et al. characterized the NeoChord learning curve, reporting a procedural failure rate that dropped from 25% in the initial 20 cases to 5% after the 49th case [13]. Paralleling these findings, our chronological split demonstrated an upward trend in repair durability, with 1- and 2-year freedom from ≥ grade 2 MR rising from 75.0% and 61.4% in the first 16 cases to 80.0% and 72.7% in the final 15 cases. This gain reflects growing technical familiarity, though the modest cohort size precludes statistical significance. Importantly, we maintained strict selection criteria throughout the study—prioritizing posterior leaflet pathology while excluding significant annular dilatation or calcification—and utilized proctor supervision during the initial learning phase to safeguard procedural outcomes.

In our series, a single patient (3.2%) underwent reoperation during the first postoperative year secondary to acute neochord rupture, aligning well with the 0% to 5% reoperation rates documented in similar surgical cohorts [9, 13, 17]. In their multicenter analysis, Colli et al. observed that 25% of patients experiencing recurrent MR eventually required surgical re-intervention, with nearly four-fifths of these failures emerging early in the postoperative course [14]. Notably, the subset of our patients presenting with residual or recurrent moderate MR during mid-term surveillance did not require re-intervention. This conservative approach was justified by stable ventricular dimensions, preserved LVEF, and the absence of clinical symptoms.

Choice between NeoChord, robotic mitral valve surgery, and M-TEER at our institution was shaped by both anatomical and health-system factors. Patients with isolated or multiple posterior scallop involvement, without annular dilatation or calcification, were considered for NeoChord as a first-line strategy after counseling regarding expected mid-term durability; patients with anatomy less favorable for a ringless chordal repair were instead referred for minimally invasive robotic mitral valve surgery, our institution's standard alternative to conventional sternotomy during the study period [27]. M-TEER was not available at our center, as it was not a reimbursable procedure within the Turkish state-hospital Social Security Institution payment framework (SUT) during the study interval, a constraint that continues to shape device selection at government-funded centers

in our country. An additional consideration favoring NeoChord in anatomically eligible patients is that, because the procedure is performed through a left mini-thoracotomy without sternotomy or aortic manipulation, it does not compromise subsequent access to the mitral valve through alternative approaches should reintervention become necessary; this is consistent with reports describing safe, low-morbidity reintervention—including repeat minimally invasive chordal repair—after an initial surgical mitral repair has failed [28].

Because significant mitral annular dilatation served as a baseline exclusion criterion, its direct influence on repair durability could not be tested in our cohort. Unlike conventional open or robotic annuloplasty, NeoChord repair does not stabilize the mitral ring. Previous studies utilizing the leaflet-to-annulus index demonstrate that a dilated annulus relative to leaflet coverage compromises coaptation length, predisposing to residual or recurrent MR after chordal-only procedures [30]. Consequently, we consider marked annular remodeling a relative contraindication for standalone NeoChord implantation, reserving ring-based repair for these complex anatomies. While this selective strategy optimized our perioperative outcomes, it naturally restricts the generalizability of our findings to patients with advanced annular dilation.

Financial sustainability remains a critical factor within state-funded healthcare systems. During our study interval, the national reimbursement tariff (SUT) rendered NeoChord implantation more cost-efficient than robotic mitral surgery, establishing it as our preferred minimally invasive option for anatomically suitable cases. Subsequent revisions to SUT coverage have since restricted NeoChord utilization primarily to private institutions in Türkiye. In response to these shifting financial conditions, our practice has incorporated direct-vision minimally invasive repair via a right anterior mini-thoracotomy as a non-robotic alternative, while maintaining a primary preference for robotic repair when feasible. These evolving reimbursement models must be acknowledged when contextualizing our practice patterns relative to other healthcare systems.

The single patient with a history of infective endocarditis in our cohort had completed a full course of targeted antimicrobial therapy, with complete resolution of clinical and laboratory markers prior to surgery. Preoperative echocardiography confirmed the absence of vegetations or annular abscess formation. Valve repair was prioritized over prosthetic replacement in line with established evidence demonstrating lower long-term mortality and lower reinfection rates when repair is technically feasible [29]. No infection-related recurrences or complications occurred during

follow-up. Nevertheless, active or recent endocarditis—particularly when accompanied by annular or leaflet tissue destruction—requires extreme caution before contemplating a ringless chordal repair, and our positive outcome remains limited to a single, highly selected case.

Several methodological limitations warrant consideration. First, the single-center, retrospective design and relatively small sample size naturally constrain statistical power. Second, our strict candidacy criteria—specifically excluding significant annular dilatation and calcification—likely yielded higher success rates than would be expected in unselected or anatomically complex cohorts. Third, variable follow-up intervals, one patient lost to follow-up, and the reduction of at-risk patients beyond two years limit the certainty of long-term Kaplan-Meier projections. Fourth, our health-economic insights stem from specific national reimbursement frameworks (SGK/SUT) and may not directly translate to alternative healthcare environments. Finally, multi-center prospective studies with extended follow-up remain necessary to establish true long-term durability.

Conclusion

Transapical NeoChord repair is a safe, off-pump option for well-selected patients, particularly those with isolated posterior leaflet prolapse and no annular dilatation. However, our time-to-event analysis shows that mid-term durability is more limited than standard cross-sectional reporting suggests. Long-term success depends on careful patient selection, initial proctor guidance, honest patient counseling about recurrence risks, and regular echocardiographic follow-up. If intraoperative results are not ideal or annular dilatation is present, converting to a conventional or robotic ring-based repair should not be delayed. Finally, larger prospective studies with longer follow-up are needed to fully evaluate the long-term durability of this technique compared to other repair options.

Declarations

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Consent to participate: The requirement for individual informed patient consent was waived by the Ethics Committee owing to the retrospective nature of the study.

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Data availability: The data underlying this article will be shared on reasonable request to the corresponding author.

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Supplementary Video 1. A video demonstrating the transapical beating-heart mitral valve repair procedure using the NeoChord DS1000 system, as performed at our clinic.

Table 1. Patient baseline characteristics and comorbidities.

Variable	N (%) or mean ± SD (range)
Age (years)	57.1 ± 14.0 (31–83)
Male	27 (87.1)
BMI (kg/m²)	25.7 ± 3.6
EuroSCORE II	
< 2 (Low risk)	22 (71.0)
2–6 (Moderate risk)	8 (25.8)
> 6 (High risk)	1 (3.2)
Comorbidities	
Hypertension	11 (35.5)
Diabetes mellitus	5 (16.1)
Atrial fibrillation	5 (16.1)
Congestive heart failure	4 (13.0)
Cerebrovascular disease	2 (6.5)
Hypothyroidism	2 (6.5)
COPD	1 (3.2)
Previous cardiac surgery	2 (6.5)
Infective endocarditis	1 (3.2)
Renal disease	1 (3.2)
NYHA Functional Class	
Class I	4 (12.9)
Class II	10 (32.3)
Class III	16 (51.6)
Class IV	1 (3.2)

BMI: body mass index, COPD: chronic obstructive pulmonary disease, EuroSCORE: European System for Cardiac Operative Risk Evaluation, NYHA: New York Heart Association, SD: standard deviation.

Table 2. Preoperative echocardiographic findings.

Echocardiographic parameter	N (%) or mean ± SD
LVEF (%)	61.5 ± 4.5 (50–69)
LVEF ≤ 60%	14 (45.1)
LVEF > 60%	17 (54.9)
Mitral Regurgitation Grade	
Grade 3	11 (35.5)
Grade 4	20 (64.5)
Prolapsed Segment	

P2	24 (77.4)
P2–P3	4 (13.0)
P1–P2	1 (3.2)
A1–P1–P2	1 (3.2)
A2	1 (3.2)
Anatomical Classification	
Type A (isolated central posterior leaflet)	24 (77.4)
Type B (extended posterior leaflet prolapse)	5 (16.1)
Type C (anterior or bileaflet prolapse)	2 (6.5)
Type D (paracommissural / calcification)	0
Left atrial diameter (mm)	42.7 ± 3.7 (32–52)
Left Atrial Enlargement	
Normal	8 (25.8)
Mild	19 (61.3)
Moderate	3 (9.7)
Severe	1 (3.2)
Tricuspid Regurgitation	
None	6 (19.4)
Minimal	8 (25.8)
Grade 1	16 (51.6)
Grade 2	1 (3.2)

LVEF: left ventricular ejection fraction, MR: mitral regurgitation. Left atrial diameter is presented adjacent to the corresponding categorical Left Atrial Enlargement grading.

Table 3. Perioperative data.

Parameter	Mean ± SD (range) or N (%)
Operative time (min)	122.2 ± 14.3 (94–155)
Number of Neochords Implanted	
2	2 (6.5)
3	9 (29.0)
4	15 (48.3)
5	2 (6.5)
6	2 (6.5)
7	1 (3.2)
Mechanical ventilation time (hours)	3.3 ± 1.8 (1–9)
Chest tube drainage (milliliter)	220 ± 138 (50–600)
ICU stay (hours)	16.9 ± 4.0 (12–27)

Hospital stay (days)	6.0 ± 2.1 (4–14)
30-day mortality	0
New-onset atrial fibrillation	3 (9.7)
MR Grade at Discharge	
Minimal	21 (67.8)
Grade 1	9 (29.0)
Grade 2	1 (3.2)
Grade 3–4	0

ICU: intensive care unit, MR: mitral regurgitation, SD: standard deviation.

Table 4. Cross-sectional echocardiographic follow-up findings at fixed intervals.

MR Grade	3 months (n=30)	1 year (n=30)	Mid-term (n=29)
Minimal	11 (36.7%)	4 (13.3%)	3 (10.3%)
Grade 1	10 (33.3%)	10 (33.3%)	6 (20.7%)
Grade 1–2	8 (26.7%)	10 (33.3%)	9 (31.0%)
Grade 2	1 (3.3%)	5 (16.7%)	10 (34.5%)
Grade 3	0	1 (3.3%)	1 (3.5%)

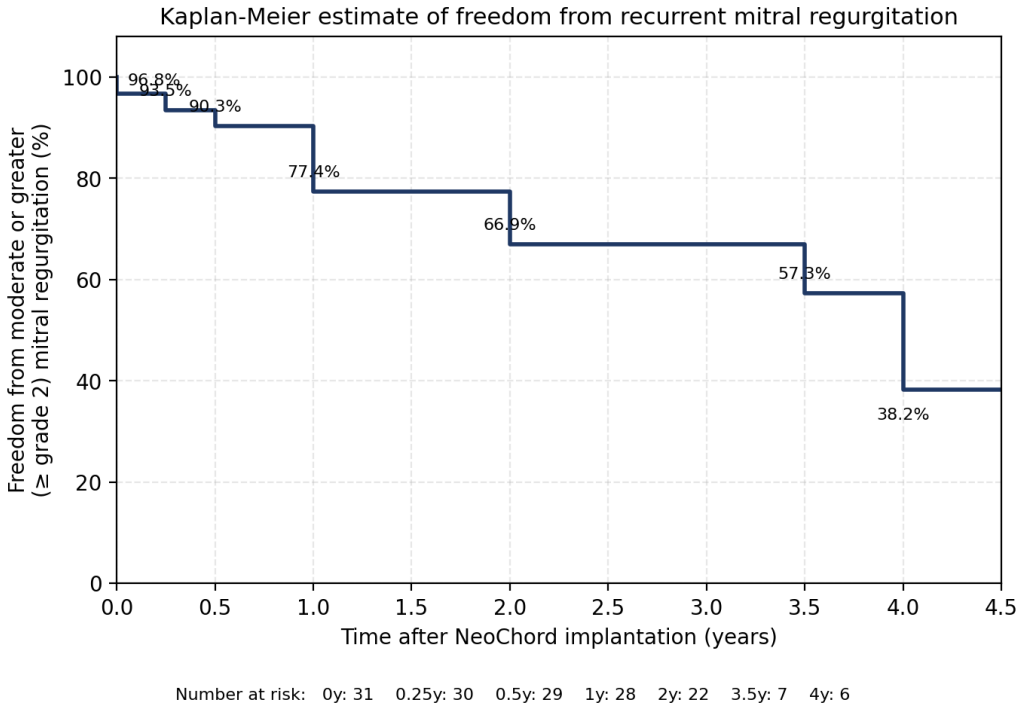
MR: mitral regurgitation. Mid-term follow-up extended up to 4 years. One patient lost to follow-up was excluded from the 3-month and 1-year data; one reoperated patient was excluded from the mid-term data. These proportions are cross-sectional (based on the status at each fixed visit) and should be interpreted alongside the Kaplan-Meier time-to-event estimates in Table 5.

Table 5. Kaplan-Meier estimate of freedom from moderate or greater (≥ grade 2) mitral regurgitation.

Time point	N at risk	Cumulative events	Freedom from ≥ grade 2 MR (%)
Discharge (t=0)	31	1	96.8
3 months	30	1	93.5
6 months	29	1	90.3
1 year	28	4	77.4
2 years	22	3	66.9
3.5 years	7	1	57.3
4 years	6	2	38.2

Event defined as the first echocardiographic documentation of ≥ grade 2 mitral regurgitation at any assessed interval, including discharge. One patient with grade 2 MR at discharge who was subsequently lost to follow-up was included as an event at t=0. Estimates beyond 2 years are based on a small number of patients remaining at risk (Figure 1) and should be interpreted with caution.

Figure 1. Kaplan-Meier curve for freedom from moderate or greater mitral regurgitation.



Numbers at risk are shown at each time point. Step decreases correspond to newly detected events of ≥ grade 2 mitral regurgitation.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Neochord.mp4