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Early Follow-up of Roman Arch Mitral Valve Repair Technique: The Paris Experience

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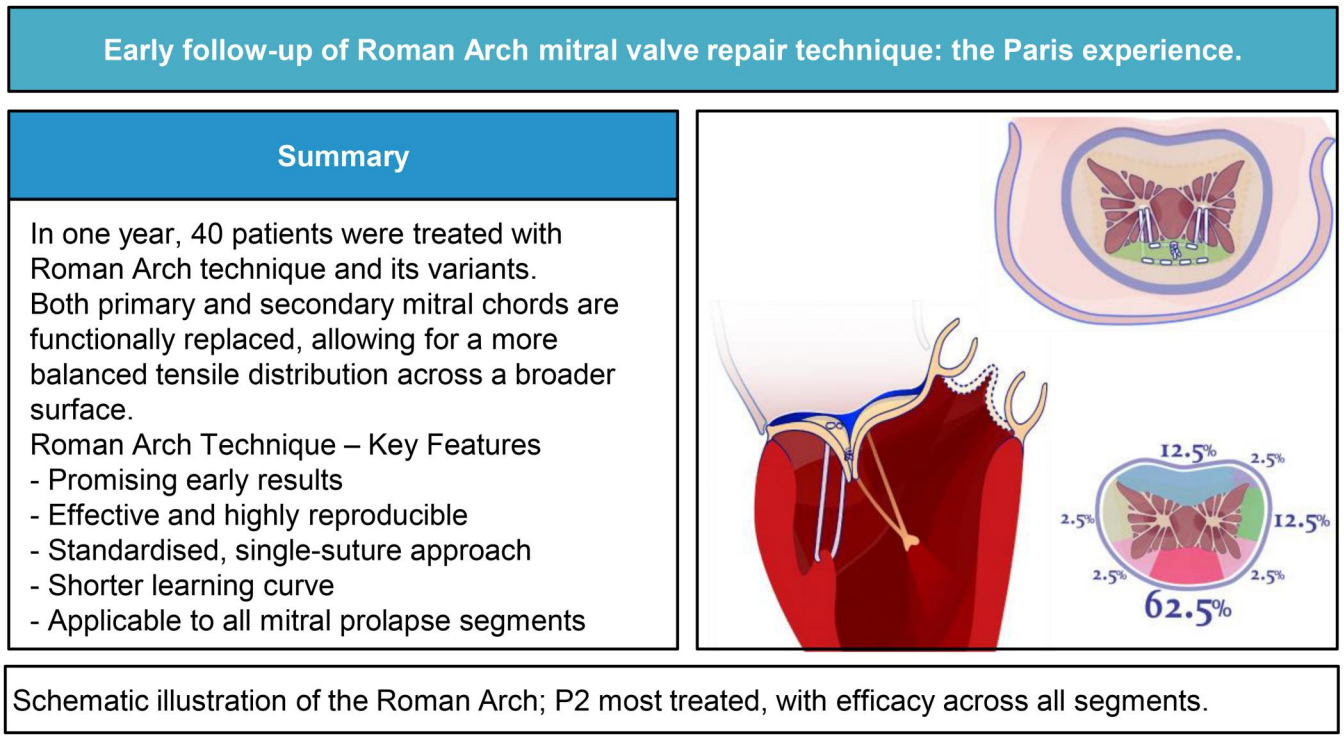
Graphical abstract



Abstract

Objectives: Degenerative mitral valve disease presents peculiar surgical challenges in patients presenting with mitral regurgitation. We reviewed the early results of a novel set of techniques to validate the feasibility for patients who underwent mitral valve repair.

Methods: Between January 2024 and December 2024, 40 patients underwent mitral valve repair using artificial neochordal implantation following the principles of the Roman Arch technique. The original technique was modified in order to treat any mitral prolapse. We

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retrospectively reviewed the early post-operative clinical outcomes, and follow-up echocardiographic data.

Results: Successful mitral valve repair was performed in all patients. Mean aortic cross-clamp time was 74 ± 18 min while cardiopulmonary bypass time was 108 ± 23 min. Mitral valve repair techniques consisted of ring annuloplasty and the Roman Arch technique, oftenly adapted to treat multiple prolapsing segments. There were no peri-operative deaths nor there was any 30-day mortality recorded. One patient (2.5%, 95% CI: 0.06%-13.2%) needed mitral valve reintervention due to infective endocarditis occurred at 8 months after the index surgery. During the echocardiographic follow-up (9 ± 3 months) only 2 patients (5%, 95% CI: 0.6%-16.9%) presented a recurrent mitral regurgitation (grade II).

Conclusions: In this initial experience, the Roman Arch technique, based on a single running suture, showed promising results as a technically simple and highly reproducible approach for mitral valve repair. Early echocardiographic outcomes were satisfactory. However, due to the limited sample size and short-term follow-up, larger and prospective studies are needed to confirm its long-term effectiveness and potential role within the spectrum of modern mitral valve repair strategies.

Keywords: mitral valve regurgitation; mitral valve repair; surgical techniques.

INTRODUCTION

With an estimated prevalence varying from 2% to 3% in the general population[1,2] and a wide range of causes, clinical features, and complications, mitral valve prolapse presents with a marked heterogeneity of symptoms and clinical findings[3]; when associated with mitral regurgitation, combined with symptoms and/or left ventricular dilatation and impairment, it often represents a surgical challenge. Surgical repair is universally accepted as the "gold standard" therapy of mitral disease,[4] anyhow the technical landscape of mitral repair is overfilled by the contribution of decade's long experiences and refinements. In this scenario, choosing the correct repair strategy becomes indeed a challenge itself.

Historically, 2 distinct surgical approaches have developed in mitral valve repair: the "Resect" approach, which focuses on resection techniques involving triangular or quadrangular excisions of excess valvular tissue,[5-8] and the "Respect" approach, which emphasizes leaflet preservation through the use of single or multiple artificial chordae tendineae.[9-17] Both strategies, typically combined with annuloplasty, have proven effective in achieving durable and efficient coaptation between the anterior and posterior mitral leaflets.[18-21]

Since the description of a novel set of techniques by Kofidis,[22,23] we embraced this philosophy at our institution, thus resulting in a shift from a resection-only strategy towards an approach which encompass the resuspension of the prolapsing leaflet with a single running suture. The underlying concept of Kofidis's techniques is the standardization of the procedure, reduction of variability, and guesswork elimination, by following a pattern, rather than variable moves and many individual cords.

Compared to conventional repair strategies, which often rely on multiple, technically demanding manoeuvers such as triangular or quadrangular resection, the Roman Arch technique may offer important practical advantages. Its design favours standardization and highly reproducibility, and it is potentially applicable to prolapse involving any mitral leaflet segment. Moreover, the simplicity of the single running suture may facilitate a potentially shorter learning curve, making the approach appealing for both experienced surgeons and those in training. Additionally, the use of standard materials may contribute to favourable cost-effectiveness, further supporting its integration into surgical practice.

We, therefore, sought to report the early outcomes of this new repair philosophy in a consecutive cohort of patients with severe mitral regurgitation.

METHODS

Study population

Between January 2024 and December 2024, 83 consecutive patients underwent mitral valve repair by a single surgeon at our institution. Patients were included if the Roman Arch technique or any of its variants were employed in the repair strategy. Patients were excluded from the final cohort if they underwent any resection technique, or any different neochordal implantation technique. The final study group included 40 patients treated with a prosthetic ring implantation and the resuspension of the prolapsing segment of the mitral valve with the running suture technique. Selection of this technique was made intraoperatively, based on the surgeon's real-time assessment of valve anatomy and lesion complexity.

As the Roman Arch method is still evolving, definitive lesion-based inclusion criteria have not yet been fully established.

Patients with extensive calcification, significant leaflet restriction, rheumatic involvement, or requiring complex annular or subvalvular reconstruction were typically not considered suitable candidates. In addition, standard techniques such as triangular or quadrangular resection were preferred when leaflet morphology and tissue quality were more suitable for those approaches.

Ethical statement

This is a retrospective observational study. The study had no influence on patient care and did not require formal approval from the institutional ethics committee. All data were collected as part of routine clinical care. No identifiable patient information was stored or processed in an electronic format.

Echocardiographic analysis

All patients underwent comprehensive transthoracic 2D echocardiography during the pre-operative assessment, before discharge, and at follow-up visits.

Real-time 3D transoesophageal echocardiography was performed with an EPIQ CVx ultrasound system equipped with an xMATRIX array transducer X8-2t (Philips Healthcare, Andover, MA) both during the pre-operative assessment and peri-operative analysis.

All patients underwent echocardiographic examination using a standardized protocol for the pre-operative evaluation of the

leaflets and annular pathology, as well as the quantification and description of the regurgitation. The left ventricular ejection fraction was calculated using the Simpson's biplane method and the severity of mitral regurgitation was assessed according to established guidelines employing a multi-parametric approach and was categorized as mild (1+), mild-moderate (2+), moderate-severe (3+), and severe (4+).[24,25] Mitral valve prolapse was defined as the presence of excess leaflet tissue and leaflet thickening greater than 5 mm, with a systolic displacement of at least 2 mm into the left atrium in the parasternal long-axis view.

Data collection

Pre-operative, intraoperative, and post-operative data were gathered from a computerized prospective patient database at our center. Clinical follow-up data were collected during routine post-operative visits at our center or affiliated institutions, as well as through telephone interviews. All echocardiographic data were collected at our institution, as all follow-up echocardiographic examinations were performed at our centre.

Surgical technique

The cohort represents the result of a single surgeon expert in mitral valve surgery, who consistently had an annual case volume >75 over the last 5 years. All isolated atrioventricular valve repairs were performed via right mini-thoracotomy. Concomitant tricuspid valve surgery was performed according to current guidelines[4] when regurgitation was deemed significant (≥grade 2) or in the context of annular dilatation (diameter ≥40 mm or ≥21 mm/m^2 indexed on body surface area). Full median sternotomy was performed when concomitant myocardial revascularization (CABG) was indicated after Heart Team evaluation.

Cardiopulmonary bypass was established by cannulation of both right femoral artery and vein for minimally invasive approach or in a standard fashion when concomitant CABG was performed.

Myocardial protection was achieved by administration of Del Nido or Custodiol cardioplegia during minimally invasive procedures or by the administration of intermittent cold blood cardioplegia when concomitant CABG was performed.

All mitral valve exposures were obtained via left atrial incision after the dissection of the Sondergaard's groove.

The original Roman Arch technique[22,23] is based on the execution of a single Gore-Tex running suture that originates from one of the papillary muscles, ascends to the prolapsing P2 or A2 leaflet, and descends to the other papillary muscle, thus creating the geometrical frame of the future coaptation zone. Specifically, the first step of our 4-0 Gore-Tex suture starts through the posteromedial papillary muscle, ascending with one end at the edge of the leaflet's rough zone, traversing the entire prolapsing P2 segment with multiple stitches, and finally descending to the anterolateral papillary muscle. Once this first half of the arch is completed, the same end of the suture is advanced along the free margin of P2 up to the midpoint of the leaflet, while the other end of the suture ascends from the posteromedial papillary muscle, navigating the free margin towards the midpoint (**Figure 1**). Subsequently, like any other chordal

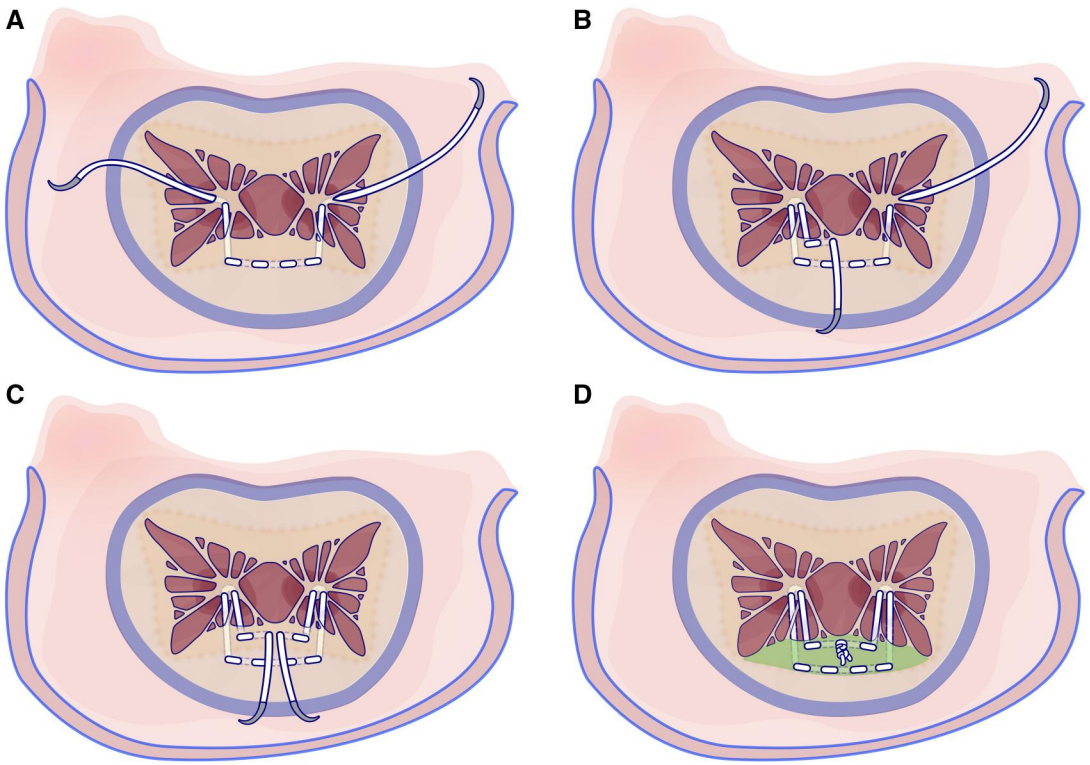

Figure 1. Schematic Step-By-Step Illustration of the Roman Arch Approach. (A) 4-0 Gore-Tex suture starts through the posteromedial papillary muscle, ascending with 1 end at the edge of the leaflet's rough zone, traversing the prolapsing P2 segment with multiple stitches and finally descending to the anterolateral papillary muscle. (B) The same end of the suture is advanced along the free margin of P2 up to the midpoint of the leaflet. (C) The other end of the suture ascends from the posteromedial papillary muscle, navigating the free margin towards the midpoint. (D) Subsequently both neochordal length and tension are adjusted and once satisfactory valve competence is confirmed, the Gore-Tex suture is definitively tied

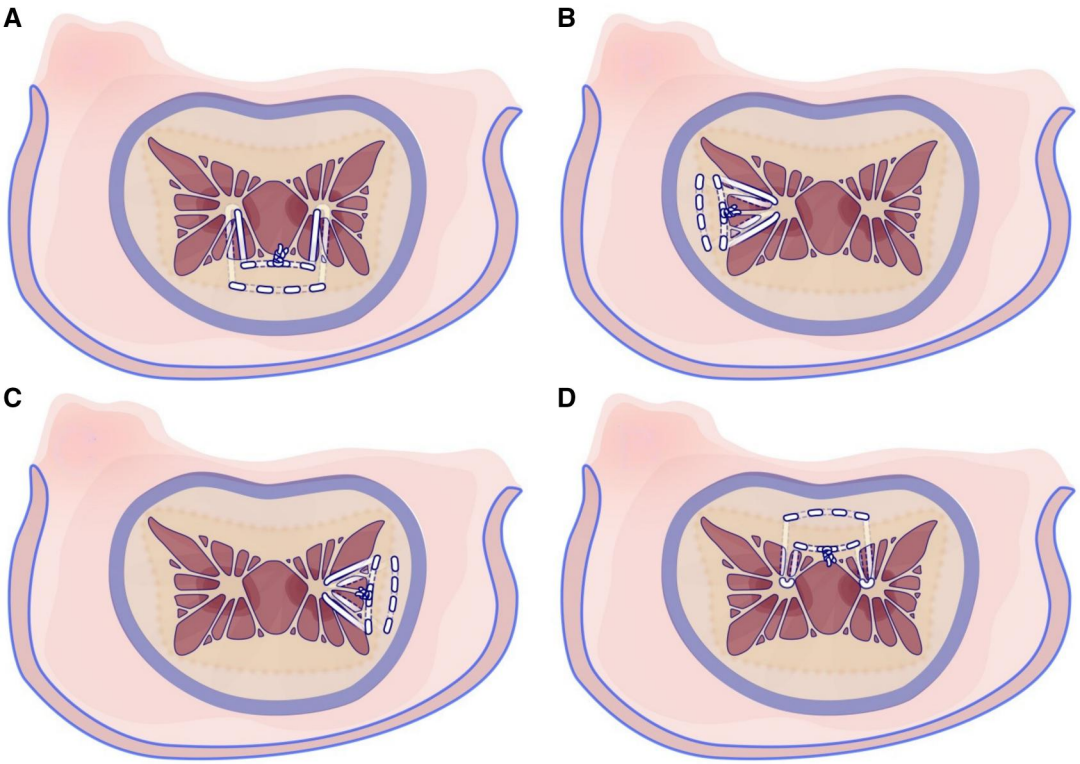

Figure 2. The Roman Arch correction as originally proposed by Kofidis (A) and the subsequent modified technique in order to treat P1 prolapse (B), P3 prolapse (C), or A2 prolapse (D)

replacement, both neochordal length and tension are adjusted, after pressurization of the left ventricular chamber with a conventional saline test, in order to allow an adequate coaptation. Once satisfactory valve competence is confirmed, the Gore-Tex suture is definitively tied.

In order to treat prolapsing segments other than P2 and A2, we borrowed the same principle of the original roman arch choosing to converge the running suture on a single papillary head.

In case of a pathological prolapse involving P1/A1 or P3/A3 segments, our variant of the technique has the anterolateral or the posteromedial papillary muscle, respectively, as a single landmark and anchoring site of the arch. Once arising from the selected papillary head and navigated the prolapsing leaflet, our suture descends on the same papillary muscle and then completes the arch in the described fashion (**Figure 2**). An annuloplasty with a complete semi-rigid ring completed all the procedures.

Study end-points

The primary end-point of our study was freedom from recurrent mitral valve regurgitation. Secondary end-points were all-cause mortality, freedom from mitral valve reintervention, and major adverse valve related event according to Guidelines for reporting mortality and morbidity after cardiac valve intervention.[26]

Statistical methods

Data are expressed as mean ± standard deviation (SD), median (interquartile range), or percentage, as appropriate. Continuous variable were tested by the Kolmogorov-Smirnov test for normal distribution. All data analyses were performed using SPSS version 26.0 (IBM Corp., Armonk, NY). Exact 95% confidence intervals for event rates were calculated using the Clopper-Pearson method.

RESULTS

Eighty-three patients underwent mitral valve repair by a single surgeon in our institution; 40 patients (48%) met the inclusion criteria and were analysed in our cohort. The baseline characteristics of this population along with echocardiographic and operative data are summarized in **Tables 1-4**.

The mean age at the time of operation of was 58.5 years, with a strong prevalence of male patients (80% of the total). Overall, the cohort exhibited a low burden of comorbidities: 50% had mild hypertension and 5% had diabetes mellitus with a low estimated operative risk (euroSCORE II: 0.93 ± 0.67%). Mean left ventricular ejection fraction was 63.9 ± 5.3%.

Minimally invasive surgery was conducted via right minithoracotomy in 37 patients (92.5%), while 3 patients (7.5%) underwent median sternotomy in order to perform concomitant total arterial myocardial revascularization. One patient required tricuspid valve annuloplasty and 2 patients underwent atrial fibrillation ablation and left atrial appendage exclusion.

Annuloplasty was performed using a complete ring for all patients (mean size being 33.0 ± 3.8 mm), utilizing the Carpentier-Edwards Physio II (Edwards Lifesciences, Irvine, CA, United States) and Medtronic SimuForm Annuloplasty Rings (Medtronic, Minneapolis, MN, United States).

Mean cardiopulmonary bypass and cross-clamp time were 110 and 74 min, respectively.

Table 1. Patient Demographics and Data

		Roman Arch mitral repair N = 40 (%)
Age (years)	Median (IQR)	59.5 (50-69.5)
Gender (males)	*n* (%)	32 (80%)
NYHA functional class		
I	*n* (%)	9 (22.5%)
II	*n* (%)	27 (67.5%)
III	*n* (%)	4 (10%)
IV	*n* (%)	0 (0%)
Hypertension	*n* (%)	20 (50%)
Diabetes mellitus	*n* (%)	2 (5%)
COPD	*n* (%)	1 (2.5%)
Dyslipidemia	*n* (%)	17 (42%)
Tabagism	*n* (%)	4 (10%)
Previous tabagism	*n* (%)	6 (15%)
Ischaemic heart disease	*n* (%)	4 (10%)
Peripheral vascular disease	*n* (%)	4 (10%)
Atrial fibrillation		
Paroxysmal	*n* (%)	4 (10%)
Long-standing persistent/permanent	*n* (%)	4 (10%)
Ejection fraction (%)	Mean ± SD	
<55%	*n* (%)	39 (97.5%)
30%-55%	*n* (%)	1 (2.5%)
SPAP		
>50 mmHg	*n* (%)	0 (0%)
31-50 mmHg	*n* (%)	11 (27.5%)
EuroSCORE II (%)	Mean ± SD	0.9 ± 0.7

Abbreviations: COPD: chronic obstructive pulmonary disease; IQR: interquartile range; NYHA: New York Heart Association; SD: standard deviation; SPAP: systolic pulmonary arterial pressure.

Table 2. Distribution of Prolapsing Mitral Valve Segments

Prolapsing leaflet	N (out of 40)	Rate (%)
Posterior leaflet	28	70
Isolated P2	21	52.5
Isolated P1	1	2.5
P1-P2	1	2.5
P2-P3	5	12.5
Anterior leaflet	3	7.5
Isolated A2	2	5
Isolated A3	1	2.5
Bileaflet prolapse	9	22.5

All patients left the operating room with no mitral regurgitation, as confirmed by the peri-operative transoesophageal echocardiographic assessment. In the entire cohort, 1 patient needed a second run of aortic cross-clamp to improve the surgical repair. In this case, once the Roman Arch corrected the prolapsing P2-P3 and A2-A3 segments, an insufficiency jet (Grade I) appeared at the indentation P1-P2 during the peri-operative control. Given the young age of the patient, we decided to treat the residual regurgitation closing the indentation with a small 5/0 polypropylene running suture in order to achieve the target result of no mitral regurgitation. There were no peri-operative deaths nor there was any 30-day mortality recorded. New onset atrial fibrillation occurred in 6 patients (15%) and the need for permanent pacemaker implantation occurred in 1 patient (2.5%).

The average intensive care unit stay was 3 days and the patients were discharged home after a mean in-hospital stay of 10 days. All patients were discharged with no more than trivial mitral regurgitation.

Early follow-up

During a mean clinical and echographic follow-up of 9 ± 3 months, no patients died. One patient (2.5%, 95% CI: 0.06%-13.2%) needed mitral valve reintervention due to infective endocarditis occurred at 8 months after the index surgery. During the echocardiographic follow-up only 2 patients (5%, 95% CI: 0.6%-16.9%) presented a recurrent mitral regurgitation (grade II). The indexed lesions of these patients were an isolate P3 prolapse due to chordal rupture and an isolated A2 prolapse due to chordal elongation, respectively. In the former case, the patients exhibited a grade II mitral regurgitation at the 6 months follow-up TTE. Mitral insufficiency jet was located at the transition between P2 and P3 segments. The latter, exhibited an eccentric grade II mitral regurgitation jet, discovered during the 4 months follow-up TTE.

Detailed echocardiographic parameters are displayed in **Table 3**.

DISCUSSION

We have shown in the results of our study that mitral regurgitation can be effectively treated with a novel reconstructive strategy[22,23] which encompasses the creation of a chordal architecture able to provide a frame for the future coaptation. Mitral valve repair has been considered both a technical and a theoretical challenge, especially in the most extreme presentations of degenerative mitral disease. Among conventional mitral valve repair techniques, the 2 main surgical approaches, the "Resect" and the "Respect" approaches, each offer distinct advantages depending on the type of prolapse. Resection techniques,[5-8] such as quadrangular or triangular resection, have been widely validated and remain highly effective for correcting prolapse of the posterior leaflet. These techniques achieve leaflet height reduction and restore an optimal coaptation surface through precise tissue removal and subsequent annuloplasty. However, resection approaches are not indicated for the treatment of anterior leaflet prolapse, where leaflet preservation is essential to maintain adequate valve function. In contrast, the "Respect" approach relies on the implantation of one or multiple artificial chordae tendineae to reposition the prolapsing leaflet without tissue excision.[9-16] This technique can also be used to treat the anterior leaflet prolapse, while preserving the native leaflet and the subvalvular apparatus.[17]

As the complexity increases, the need to combine multiple techniques may arise, potentially raising the risk of residual mitral regurgitation or even valve replacement.[18-21]

In this context, isolated anterior leaflet prolapse remains a surgical challenge. As highlighted in a recent cross-sectional study, mitral valve repair is still underused in this setting, with mitral valve replacement often preferred over repair. In fact, a large proportion of replacements are performed without any attempt

Table 3. Pre- and Post-Operative Echocardiographic Characteristics

	Pre-operative	Early post-operative	Follow-up echocardiography
LV ejection fraction (%) mean ± SD	59.9 ± 5.7	52.1 ± 8.3	56.9 ± 6.9
LV tele-diastolic volume mean ± SD	167.8 ± 36.7	111.9 ± 30.9	95.4 ± 28.5
LV tele-diastolic diameter mean ± SD	60.5 ± 7.8	51.3 ± 6.1	51.9 ± 7.7

Abbreviations: LV: left ventricle; SD: standard deviation.

Table 4. Operative Data

		Roman Arch mitral repair $N = 40$ (%)
Concomitant procedure	*n* (%)	4 (10%)
Tricuspid valve repair	*n* (%)	1 (2.5%)
Myocardial revascularization	*n* (%)	3 (7.5%)
AF ablation	*n* (%)	2 (5%)
Atrial appendage exclusion	*n* (%)	2 (5%)
Minimally invasive	*n* (%)	37 (92.5%)
Annuloplasty	*n* (%)	40 (100%)
Annuloplasty size, mm	mean ± SD	33.0 ± 3.8
26-28	*n* (%)	5 (12.5%)
30-32	*n* (%)	16 (40%)
34-36	*n* (%)	12 (30%)
38-40	*n* (%)	7 (17.5%)
Cardiopulmonary bypass, min	mean ± SD	108 ± 23
Cross-clamp time, min	mean ± SD	74 ± 18
Roman Arch site of implantation		
Anterior commissure	*n* (%)	0
A1	*n* (%)	0
A2	*n* (%)	5 (12.5%)
A3	*n* (%)	0
Posterior commissure	*n* (%)	1 (2.5%)
P1	*n* (%)	1 (2.5%)
P1-P2	*n* (%)	1 (2.5%)
P2	*n* (%)	26 (62.5%)
P2-P3	*n* (%)	1 (2.5%)
P3	*n* (%)	5 (12.5%)

Abbreviation: SD: standard deviation.

at repair, reflecting a continued reluctance to address anterior leaflet pathology with reparative strategies.[27]

The sophisticated geometric construct of the mitral valve is a dynamic entity in which every element contributes to the valvular force equilibrium. Key to obtain a durable mitral valve repair is to balance the distribution of all the forces in order to minimize the stress exerted on each individual component. Cornerstone of the fully pressurized valve is the leaflet's coaptation over a height of 5-8 mm, as a result of the dynamic interaction between the environment and the surrounding myocardial structures.

The systolic pressure exerted on the valvular surface is shared with the secondary tendinous cords, the papillary muscles, the myocardium, and the coaptation zone itself, generating a uniform distribution of the load and preventing local strain. An insufficient coaptation length will lead inevitably over time to stress imbalances and ultimately to the failure of mitral repair.

In a recent *ex vivo* study, Zhu et al[28] reported an interesting analysis on the variation of chordal forces with different neochord lengths. Although in their model MV regurgitation was successfully eliminated regardless the length of the artificial neochord implanted, a great heterogeneity of the stress imposed on the neochord was observed. The drastic increase in chordal forces observed even in the absence of mitral regurgitation should corroborate the need to focus our attention on chordal architecture in order to optimally dissipate the mechanical stress, even in the absence of mitral regurgitation.

In our study, 48% of all-comer mitral valve repairs in a solar year were treated with neochords implantation following the key principles of the "Roman Arch" technique. Although neochordal implantation was traditionally used in our practice primarily for anterior leaflet correction, the technical ease of the Roman Arch technique facilitated its broader adoption to treat prolapse of both anterior and posterior leaflet segments. Fixed landmarks as one or both papillary muscles, alongside the prolapsing segment, are the target of the correction and the respect for both the subvalvular anatomy and valve geometry were the major advantages that led us to achieve an elegant repair of multiple prolapsing segments. Both primary and secondary mitral chords are functionally replaced, allowing for a more balanced tensile distribution across a broader surface compared to standard neochordal implantation.

In our cohort the more frequent target of correction was, unsurprisingly, the P2 segment of the valve (62.5%), followed by the anterior leaflet in its central portion (12.5%). The remaining 25% of the neochordal implantations, however, occurred at P3 segment (12.5%) or at transition segments (**Figure 3**). We adopted in those cases the original technique described by Kofidis, adapted as previously described. We found this technique particularly helpful in both small independent segments and in larger multi-segmental prolapses.

In the former case, we were able to respect the delicate equilibrium of smaller segments dynamic like P1 and P3 without the need to close their indentation with the adjacent P2 scallop. Conversely, in the latter, we were able to treat adjacent segments like P1-P2, P2-P3 and the posterior commissure with a single running suture anchored to their corresponding papillary muscle.

Extensive and multi-segmental pathology embodies one of the most complex challenges in reconstructive valvular surgery because of the technical skills demanded and the plethora of techniques amongst which the surgeon must choose its strategy. Especially when multiple techniques are needed and combined, every element need to orchestrate its function and dynamic in order to obtain a balanced correction. The extent and the type of leaflet resection and/or the adjusting the optimal length of multiple neochords are crucial step in complex repair strategy and partial failure of only 1 of these elements could threaten the long-term result of the repair. The possibility to adaptively share the chordal tension on a larger surface reduces the need to

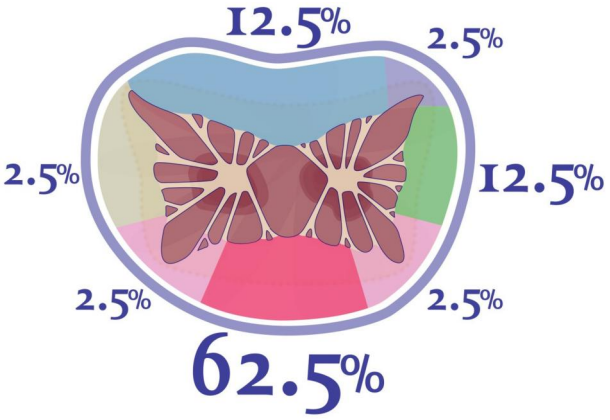

Figure 3. Neochordal Implantation Were Heterogeneously Distributed in the Entire Cohort, with a Prevalent Correction of the P2 Segment (62.5%), Followed by the Anterior Leaflet (12.5%). The remaining 25% of the neochordal implantations occurred at P3 segment (12.5%) or at transition segments and commissural regions

combine multiple techniques, demanding to find only the appropriate length of a single thread.

With the modified Roman Arch we were able to provide with few anatomic landmarks a simple repair with a single running suture which simplified our surgical strategy from a conventional multi-parametric problem to a mono-parametric one.

Moreover, this simplified and standardized approach appears to offer potential advantages in terms of learning curve and cost-effectiveness. Based on our initial experience, the technique is relatively easy to adopt, potentially reproducible across different surgical teams, and does not require additional material beyond standard neochordal sutures, which may further support its cost-effectiveness. However, these observations remain preliminary and should be validated in larger, prospective studies.

If the promising early results of the Roman Arch technique are confirmed in larger and long-term studies, this approach could become a valuable addition to the armamentarium of Respect-based mitral valve repair techniques. Its standardized and highly reproducible nature may reduce inter-operator variability, contribute to simplifying mitral valve repair and support broader adoption, even in lower-volume centres.

During our early follow-up, only 1 patient (2.5%) needed MV reintervention due to the development of a new valvular disease such as infective endocarditis and was not deemed as technical failure.

Conversely, during follow-up, recurrent mitral regurgitation (grade II) was observed in 2 patients. The indexed lesions of these patients were an isolated P3 prolapse due to chordal rupture and an isolated A2 prolapse due to chordal elongation, respectively. In the first case, a grade II mitral regurgitation was detected at the 6-month follow-up TTE, with the insufficiency jet located at the transition between P2 and P3 segments. In the second case, an eccentric grade II mitral regurgitation jet was identified at the 4-month follow-up TTE.

Limitations

This is a retrospective study, major limitations are found in its nature but also in the extent of the echocardiographic follow-up. The novel technique described by Kofidis was introduced gradually into our practice and the learning curve experience was not censured, thus affecting both intraoperative results and the overall follow-up. All procedures were performed by a single experienced surgeon, which may introduce operator-dependent bias and limit the generalizability of the findings. This granularity must be addressed in further multi-centric studies in order to reduce the operator bias, before definite conclusion can be drawn.

Out of the 83 patients who underwent mitral valve repair in 2024, only 40 were included in this analysis based on the post hoc identification of those treated with the Roman Arch technique. This selective inclusion reflects the retrospective nature of the study and may have introduced selection bias.

An additional limitation relates to the potential selection bias inherent in the choice of repair strategy. The decision to apply the Roman Arch technique was made intraoperatively, based on the lesion complexity and the surgeon's judgement of suitability for this approach. Specific exclusion criteria included extensive leaflet calcification, significant leaflet restriction or retraction, rheumatic valve involvement, and the need for complex annular or subvalvular reconstruction. In addition, in cases where the leaflet morphology or tissue quality favoured traditional resection techniques, these approaches were preferred. This selective approach was necessary during this initial experience with the technique but may limit the generalizability of the current findings and emphasizes the need for prospective comparative studies.

Regarding follow-up data collection, it should be noted that all echocardiographic follow-up examinations were performed at our institution. Telephone interviews were used solely to gather information regarding patients' clinical condition and the occurrence of any new symptoms or complications, but not for the collection of echocardiographic data. This approach ensured a high level of consistency in imaging interpretation across the cohort, although the single-centre nature of the study may limit the generalizability of our findings.

The early-term duration of follow-up, combined with the variability in echocardiographic assessments due to the continuous scheduling of surgeries across the calendar year, represents an additional limitation. These aspects underscore the need for future prospective and comparative studies with standardized and longer-term follow-up to better assess both the durability and the performance of the Roman Arch technique compared to other well-established mitral repair strategies.

CONCLUSION

The single running suture technique, as proposed by Kofidis, has shown promising results as an effective and highly reproducible approach for mitral valve repair in this initial experience. It is technically straightforward, potentially applicable to all prolapsing segments of the mitral leaflets, and highly standardized. These characteristics suggest that the technique may be associated with a shorter and more accessible learning curve compared to traditional multi-step approaches. Early echocardiographic outcomes were very satisfactory, with a low rate of recurrent mitral regurgitation. Nevertheless, further validation through longer follow-up and larger, possibly multi-centric, studies are required to confirm these promising results and to fully define its long-term durability and educational impact. If confirmed, the Roman Arch technique could contribute to simplifying mitral valve repair and enhancing its reproducibility and broader adoption across surgical practice.

AUTHOR CONTRIBUTIONS

K.Z.: Conceptualization; Methodology; Project administration; Writing—review and editing. P.M.: Conceptualization; Investigation; Formal analysis; Methodology; Data curation; Writing—original draft. R.B.: Conceptualization; Formal analysis; Writing—original draft; Visualization. N.K.: Supervision; Validation. M.R.: Investigation; Formal analysis; Data curation. T.T.: Methodology; Writing—review and editing. A.B.: Investigation; Supervision; Data curation; Validation. T.K.: Writing—review and editing; Supervision

FUNDING

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CONFLICTS OF INTEREST

None declared.

DATA AVAILABILITY

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

REFERENCES

[1] Freed LA, Levy D, Levine RA, et al. Prevalence and clinical outcome of mitral-valve prolapse. *N Engl J Med*. 1999;341:1-7. https://doi.org/10.1056/NEJM199907013410101
[2] Delling FN, Vasan RS. Epidemiology and pathophysiology of mitral valve prolapse: new insights into disease progression, genetics, and molecular basis. *Circulation*. 2014;129:2158-2170. https://doi.org/10.1161/CIRCULATIONAHA.113.006702
[3] Hayek E, Gring CN, Griffin BP. Mitral valve prolapse. *Lancet*. 2005;365:507-518. https://doi.org/10.1016/S0140-6736(05)17869-6
[4] Vahanian A, Beyersdorf F, Praz F, et al. ESC/EACTS Guidelines for the management of valvular heart disease [published correction appears in Eur Heart J. 2022 Jun 1;43(21):2022. doi: 10.1093/eurheartj/ehac051.]. *Eur Heart J*. 2022;43:2022. https://doi.org/10.1093/eurheartj/ehab395
[5] Carpentier A. Cardiac valve surgery—the "French correction". *J Thorac Cardiovasc Surg*. 1983;86:323-337.
[6] Burns DJP, Suri RM, Gillinov AM. Targeted triangular resection for repair of degenerative mitral valve disease. *JTCVS Tech*. 2021;10:47-52. https://doi.org/10.1016/j.xjtc.2021.09.049
[7] Sakamoto Y, Hashimoto K, Okuyama H, et al. Long-term assessment of mitral valve reconstruction with resection of the leaflets: triangular and quadrangular resection. *Ann Thorac Surg*. 2005;79:475-479. https://doi.org/10.1016/j.athoracsur.2004.07.046
[8] Ma J, Liu J, Wei P, et al. Quadrangular resection versus chordal replacement for degenerative posterior mitral leaflet prolapse. *Ann Transl Med*. 2021;9:60. https://doi.org/10.21037/atm-20-7475
[9] Perier P, Hohenberger W, Lakew F, et al. Toward a new paradigm for the reconstruction of posterior leaflet prolapse: midterm results of the "respect rather than resect" approach. *Ann Thorac Surg*. 2008;86:718-725. https://doi.org/10.1016/j.athoracsur.2008.05.015
[10] Caldonazo T, Sá MP, Jacquemyn X, et al. Respect versus resect approaches for mitral valve repair: a meta-analysis of reconstructed time-to-event data. *Am J Cardiol*. 2024;213:5-11. https://doi.org/10.1016/j.amjcard.2023.12.010
[11] Chua YL, Pang PY, Yap YP, Abdul Salam ZH, Chen YT. Chordal reconstruction versus leaflet resection for repair of degenerative posterior mitral leaflet prolapse. *Ann Thorac Cardiovasc Surg*. 2016;22:90-97. https://doi.org/10.5761/atcs.oa.15-00322
[12] Di Mauro M, Bonalumi G, Giambuzzi I, et al. Mitral valve repair with artificial chords: tips and tricks. *J Card Surg*. 2022;37:4081-4087. https://doi.org/10.1111/jocs.17076
[13] Moore RA, Gillinov AM, Burns DJ, Pettersson GB, Wierup P. Techniques for mitral valve re-repair. *Oper Tech Thorac Cardiovasc Surg*. 2021;26:42-65. https://doi.org/10.1053/j.optechstcvs.2020.09.004
[14] Lang M, Vitanova K, Voss B, et al. Beyond the 10-year horizon: mitral valve repair solely with chordal replacement and annuloplasty. *Ann Thorac Surg*. 2023;115:96-103. https://doi.org/10.1016/j.athoracsur.2022.05.036
[15] Pasrija C, Tran D, Ghoreishi M, et al. Degenerative mitral valve repair simplified: an evolution to universal artificial cordal repair. *Ann Thorac Surg*. 2020;110:464-473. https://doi.org/10.1016/j.athoracsur.2019.10.068
[16] David TE, Armstrong S, Ivanov J. Chordal replacement with polytetrafluoroethylene sutures for mitral valve repair: a 25-year experience. *J Thorac Cardiovasc Surg*. 2013;145:1563-1569. https://doi.org/10.1016/j.jtcvs.2012.05.030
[17] Castillo JG, Anyanwu AC, El-Eshmawi A, Adams DH. All anterior and bileaflet prolapse is repairable in the current era of mitral valve reconstruction. *Eur J Cardiothorac Surg*. 2014;45:426-433.
[18] Barlow CW, Ali-Ghosh H, Sajiram S. Functional anatomy and surgical principles of mitral repair for the barlow valve: past legacy guides the future. *JTCVS Tech*. 2021;10:58-63. https://doi.org/10.1016/j.xjtc.2021.08.046
[19] Dreyfus GD, Dulguerov F, Marcacci C, et al. "Respect when you can, resect when you should": a realistic approach to posterior leaflet mitral valve repair. *J Thorac Cardiovasc Surg*. 2018;156:1856-1866.e3. https://doi.org/10.1016/j.jtcvs.2018.05.017
[20] Ben Zekry S, Spiegelstein D, Sternik L, et al. Simple repair approach for mitral regurgitation in Barlow disease. *J Thorac Cardiovasc Surg*. 2015;150:1071-1077.e1. https://doi.org/10.1016/j.jtcvs.2015.08.023
[21] Jouan J, Berrebi A, Chauvaud S, Menasché P, Carpentier A, Fabiani JN. Mitral valve reconstruction in Barlow disease: long-term echographic results and implications for surgical management. *J Thorac Cardiovasc Surg*. 2012;143:S17-S20. https://doi.org/10.1016/j.jtcvs.2011.11.016
[22] Kofidis T. A mitral valve repair update: simple, intuitive and physiological techniques, using running sutures (part I). *Eur J Cardiothorac Surg*. 2023;63:ezad032. https://doi.org/10.1093/ejcts/ezad032
[23] Kofidis T. Mitral valve repair update: simple, intuitive and physiological techniques, using running sutures (part II). *Eur J Cardiothorac Surg*. 2023;63:ezad045. https://doi.org/10.1093/ejcts/ezad045
[24] Lancellotti P, Tribouilloy C, Hagendorff A, et al.; Scientific Document Committee of the European Association of Cardiovascular Imaging. Recommendations for the echocardiographic assessment of native valvular regurgitation: an executive summary from the European Association of Cardiovascular Imaging. *Eur Heart J Cardiovasc Imaging*. 2013;14:611-644. https://doi.org/10.1093/ehjci/jet105
[25] Zoghbi WA, Adams D, Bonow RO, et al. Recommendations for noninvasive evaluation of native valvular regurgitation: a report from the American Society of Echocardiography developed in collaboration with the Society for Cardiovascular Magnetic Resonance. *J Am Soc Echocardiogr*. 2017;30:303-371. https://doi.org/10.1016/j.echo.2017.01.007
[26] Akins CW, Miller DC, Turina MI, et al.; EACTS. Guidelines for reporting mortality and morbidity after cardiac valve interventions. *Ann Thorac Surg*. 2008;85:1490-1495. https://doi.org/10.1016/j.athoracsur.2007.12.082
[27] Khairallah S, Rahouma M, Gambardella I, et al. Trends in the management of anterior mitral leaflet regurgitation. *JAMA Netw Open*. 2024;7:e246726. https://doi.org/10.1001/jamanetworkopen.2024.6726
[28] Zhu Y, Lee SH, Venkatesh A, et al. Biomechanical engineering analysis of neochordae length's impact on chordal forces in mitral repair. *Eur J Cardiothorac Surg*. 2024;65:ezae008. https://doi.org/10.1093/ejcts/ezae008

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