Aortic root remodeling after surgical repair of acute type A aortic dissection using different anastomosis techniques

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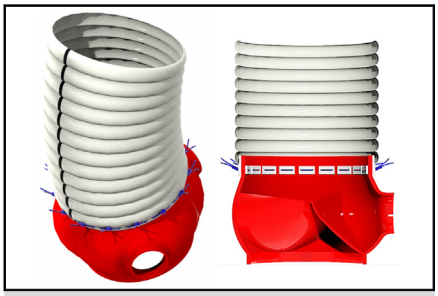
ABSTRACT

Background: After surgical repair of acute type A aortic dissection (aTAAD), remodeling of the residual aortic segments is the key outcome parameter associated with late reoperation or aorta-related adverse events. In this study, we analyzed the surgical outcomes of aTAAD using either a telescopic or continuous anastomosis technique, focusing on their impact on aortic root remodeling during the longitudinal follow-up.

Methods: Between 2012 and 2018, 112 surgical repairs of aTAAD with ascending aorta replacement and without aortic arch or aortic root replacement were performed. The medical records were reviewed retrospectively, and early and late outcomes were compared between the telescopic and continuous anastomosis techniques. The generalized estimating equation method was used to analyze the effects of different anastomosis techniques on serial aortic root remodeling.

Results: The telescopic anastomosis technique was used in 46 cases (41.1%), and the conventional continuous anastomosis technique was used in 66 cases (58.9%). There were no differences in in-hospital mortality or the incidence of major complications between the groups. The telescopic anastomosis group demonstrated stable postoperative regression of the aortic root diameter during follow-up. In contrast, the continuous anastomosis group showed a progressive dilatation of the aortic root. There was a trend toward better aortic root adverse event–free survival rates in the telescopic anastomosis group ($P = .081$).

Conclusions: The telescopic anastomosis technique is a safe alternative to the continuous anastomosis technique in the surgical repair of aTAAD, with comparable early results. In addition, telescopic anastomosis was associated with beneficial aortic root remodeling in the medium term compared with continuous anastomosis. (JTCVS Techniques 2023;21:18-25)



The telescopic anastomosis with interrupted, pledgeted, horizontal mattress sutures in aTAAD repair.

CENTRAL MESSAGE

The telescopic anastomosis technique used for proximal anastomosis in aTAAD repair has similar early outcomes and better aortic root remodeling at medium-term compared to the continuous technique.

PERSPECTIVE

Effective ways to facilitate better aortic remodeling and avoid late adverse aortic events following acute type A aortic dissection (aTAAD) surgical repair are of interest but have rarely been investigated only rarely. Our study demonstrated that different anastomosis techniques can affect the progress of aortic root dilation after aTAAD surgical repair and may result in different incidences of aortic root-related adverse outcomes.

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Abbreviations and Acronyms
aTAAD = acute type A aortic dissection
CI = confidence interval
CPB = cardiopulmonary bypass

Studies on surgical outcomes of acute type A aortic dissection (aTAAD) repair have emphasized long-term complications, such as adverse aortic remodeling and late aortic events, whereas early outcomes after aTAAD repair have shown significant improvement in recent years.[1-4] A supracommissural ascending aorta replacement is an anastomosis of a graft and the native aorta at the sinotubular junction, which has been a reasonable alternative to the more technically complex aortic root replacement in patients with aTAAD without existing aortic root aneurysm or intimal tear at the sinuses of Valsalva.[5-13] Studies have demonstrated that the late outcomes related to an unreplaced aortic root are favorable, with a low incidence of reintervention for either the root or the aortic valve. Nevertheless, progressive root dilation was observed and remained a concern for supracommissural anastomosis.[6,7,9,10,12,13]

We previously introduced a novel telescopic anastomosis technique that facilitates hemostasis during aortic surgery.[14,15] In this study, we aimed to compare telescopic anastomosis versus continuous anastomosis in supracommissural anastomosis for patients with aTAAD. We analyzed their medium-term outcomes and effects on aortic root remodeling during longitudinal follow-up.

METHODS

Study Population

Since the telescopic anastomosis technique was introduced in 2012,[14] it has been used for aTAAD repair in 2 medical centers based on surgeon preference. We retrospectively reviewed the charts of patients who underwent surgery for aTAAD between January 2012 and December 2018 in both institutions. Only those patients undergoing ascending aorta replacement with proximal anastomosis at the level of the sinotubular junction were included, such as patients who did not require aortic root replacement. Patients requiring replacement of the aortic arch or its branches were excluded.

The Institutional Review Boards of the National Cheng Kung University Hospital (A-ER-110-055; July 27, 2021) and E-Da Hospital (EMRP-109-083; August 5, 2021) approved this retrospective study and waived the requirement for patient informed consent.

Operative Technique

Except for the anastomosis techniques, the other operative techniques of aTAAD repair in both institutes have been standardized as described previously.[3,4,16] Right axillary artery cannulation was performed for most patients who did not need emergency cardiopulmonary bypass (CPB) cannulated via femoral vessels. A distal aorta to graft anastomosis with an open technique was performed first, in accordance with the latest guidelines from the American Heart Association, American College of Cardiology, American Association for Thoracic Surgery, and Society of Thoracic Surgeons.[17] We used selective antegrade cerebral perfusion at a flow rate of 10 mL/kg/min, which maintained arterial pressure between 50 and 70 mmHg under moderate (25 °C) hypothermic circulatory arrest during the distal anastomosis. Transcutaneous cerebral oximetry was monitored continuously throughout the operation.[4]

In both the telescopic anastomosis and continuous anastomosis techniques, the modified sandwich technique was used to obliterate the false lumen.[14,15,18] A tailored Teflon patch was placed into the dissected space between the media and adventitia, followed by external reinforcement using a Teflon strip surrounding the entire circle of the aortic anastomosis site. Continuous anastomosis was done using either 3-0 or 4-0 polypropylene sutures with a conventional continuous running technique (Figure 1, *A*). For the telescopic anastomosis technique, a vascular graft with a diameter 2 to 3 mm larger than the aortic diameter at the sinotubular junction was used. Twelve to 15 interrupted, pledgeted, horizontal mattress sutures with 3-0 or 4-0 polypropylene sutures were passed inside-out across the reinforced aorta 5 mm below the transected border circumferentially and through the graft with adequate spacing. Once the stitches were tied down, the vascular graft was "parachuted" down and seated outside the aorta, and the aortic wall was "telescoped" into the vascular graft (Figure 1, *B*). Tissue adhesive agents were used according to the surgeon's preference and judgment of satisfactory hemostasis.

Statistical Analysis

Categorical variables were evaluated using the χ^2 or Fisher's exact tests, and numerical variables were evaluated using the Student *t* test. At medium-term follow-up, overall survival and aortic root adverse

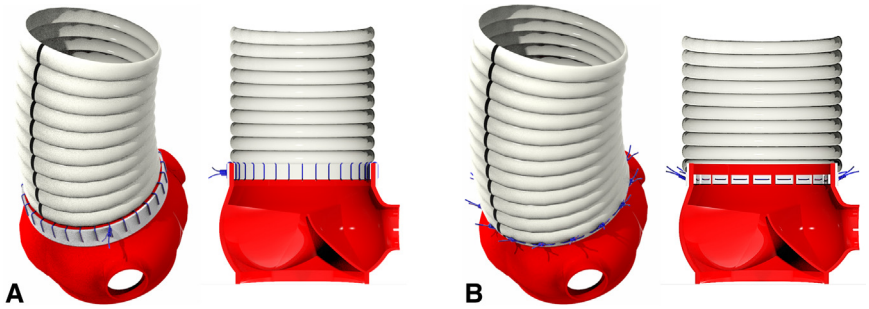

FIGURE 1. Continuous anastomosis technique (A) and telescopic anastomosis technique (B) used in surgical repair of acute type A aortic dissection. The telescopic technique involves "parachuting" the vascular graft down and seating it outside the aorta, after which the aorta is "telescoped" into the graft. The figures on the *right* are longitudinally cut-away illustrations that demonstrate the luminal side of the aorta. Note the interrupted horizontal mattress sutures enforced with pledgets used in the telescopic technique.

event–free survival were evaluated using Kaplan–Meier survival curves and the log-rank test. An aortic root adverse event was defined as an aortic root aneurysm (≥50 mm), pseudoaneurysm or residual dissection, presence of moderate or severe aortic insufficiency, or any reoperation related to the aortic root or aortic valve.

Longitudinal data on the aortic root diameter were accessed via postoperative annual contrast-enhanced computed tomography angiography scans. The maximal diameter of the aortic root, measured perpendicular to the axis of the aorta, was determined by the radiologist who produced the report, and subsequently verified by one of the authors (T.W.L.). Further analysis was conducted using the generalized estimating equation method with a first-order autoregressive correlation model. All statistical analyses were performed using PASW Statistics for Windows version 18.0 (SPSS).

RESULTS

A total of 112 patients with aTAAD underwent surgical repair by ascending aorta replacement without aortic arch vessel or aortic root replacement during the study period. The classical continuous anastomosis technique was used in 66 patients (58.9%), and the telescopic anastomosis technique was performed in 46 patients (41.1%). More patients had chronic kidney disease in the continuous anastomosis group than in the telescopic group (30.3% vs 13.0%; $P = .041$); however, there were no significant differences in any other baseline characteristics between the 2 groups (Table 1).

The procedural characteristics of both groups were significant, with longer CPB times in the telescopic anastomosis group compared with the continuous anastomosis group (mean, 271.00 ± 65.52 minutes vs 209.42 ± 89.35 minutes; $P < .001$). The telescopic anastomosis group also demonstrated significantly longer aortic cross-clamp times (mean, 164.22 ± 26.93 minutes vs 143.18 ± 50.69 minutes; $P = .005$) and longer selective antegrade cerebral perfusion times (mean, 62.28 ± 11.48 minutes vs 55.68 ± 29.10 minutes; $P = .101$). However, there were no between-group differences in short-term major complications and in-hospital mortality rates (Table 2). The implanted graft diameter was larger in the telescopic anastomosis group compared with the continuous anastomosis group (28.69 ± 2.07 mm vs 26.46 ± 2.32 mm; $P < .001$), but there were no differences in preoperative aortic root and aortic arch diameters between the 2 groups.

Ninety-eight of the 112 patients (87.5%) survived until hospital discharge. Aortic computed tomography angiography was available in 79 out of 97 patients (81.4%) who were still followed at 1 year postoperatively and in 50 out of 57 patients (87.7%) at 5 years. During follow-up, a progressive dilation of the aortic root was seen in the continuous anastomosis group, with a mean dilation rate of approximately 0.2 mm/year. In contrast, the aortic root diameter decreased by approximately 2 mm at 1 year after the initial aTAAD repair with the telescopic anastomosis technique and remained stable without dilation during follow-up. The changes in diameter were statistically different between the 2 groups at each postoperative year using the generalized estimating equation model (Figure 2, *A*). At 5 years, the mean aortic root diameter was decreased by 2.20 mm (95% confidence interval [CI], 0.70-3.70 mm) in the telescopic anastomosis group, whereas it was increased in the continuous anastomosis group (mean, 1.21 mm; 95% CI, 0.25-2.17 mm;

TABLE 1. Characteristics and clinical presentations of patients undergoing ascending aorta replacement for aTAAD between January 2012 and December 2018 (N = 112)

Characteristic	Continuous anastomosis (N = 66)	Telescopic anastomosis (N = 46)	*P* value
Age, y, mean ± SD	60.97 ± 13.17	61.10 ± 10.12	.954
Male sex, n (%)	42 (63.6)	31 (67.4)	.840
Hematocrit, %, mean ± SD	38.41 ± 6.70	39.04 ± 5.37	.597
Diabetes mellitus, n (%)	7 (10.6)	3 (6.5)	.522
Chronic kidney disease, n (%)	20 (30.3)	6 (13.0)	.041
Hemodynamic instability, n (%)	19 (28.8)	17 (37.0)	.414
Cardiac tamponade	14 (21.2)	11 (23.9)	.819
CPCR	3 (4.5)	2 (4.3)	>.999
Malperfusion, n (%)	19 (28.8)	13 (28.3)	>.999
Myocardial infarction	2 (3.0)	3 (6.5)	.400
Cerebral malperfusion	12 (18.2)	6 (13.0)	.603
Extremity malperfusion	9 (13.6)	4 (8.7)	.554
Mesenteric malperfusion	2 (3.0)	3 (6.5)	.400
Maximal aortic root diameter, mm, mean ± SD	39.08 ± 4.92	39.74 ± 6.01	.523
Maximal aortic arch diameter, mm, mean ± SD	34.05 ± 5.06	34.93 ± 5.00	.360

CPCR, Cardiopulmonary cerebral resuscitation; *aTAAD*, acute type A aortic dissection.

TABLE 2. Procedural variables and early outcomes of patients undergoing ascending aorta replacement for aTAAD between January 2012 and December 2018 (N = 112)

Variable	Continuous anastomosis (N = 66)	Telescopic anastomosis (N = 46)	*P* value
CPB time, min, mean ± SD	209.42 ± 89.35	271.00 ± 65.52	<.001
Aortic cross-clamp time, min, mean ± SD	143.18 ± 50.69	164.22 ± 26.93	.005
SACP time, min, mean ± SD	55.68 ± 29.10	62.28 ± 11.48	.101
Graft size, mm, mean ± SD	26.46 ± 2.32	28.69 ± 2.07	<.001
ECMO, n (%)	5 (7.6)	3 (6.5)	>.999
Reexploration for bleeding, n (%)	4 (6.1)	5 (10.9)	.484
Sternal wound infection, n (%)	1 (1.5)	0 (0)	>.999
Newly developed dialysis, n (%)	7 (10.6)	7 (15.2)	.565
Respiratory failure, n (%)	6 (9.1)	3 (6.5)	.735
Permanent stroke, n (%)	11 (16.7)	7 (15.2)	>.999
Major complication, n (%)	16 (24.2)	13 (28.3)	.666
In-hospital mortality, n (%)	6 (9.1)	8 (17.4)	.248

CPB, Cardiopulmonary bypass; *SACP*, selective antegrade cerebral perfusion; *ECMO*, extracorporeal membrane oxygenation; *aTAAD*, acute type A aortic dissection.

$P < .001$). In the subgroup of patients with moderate preoperative aortic root dilation (≥40 mm), the mean root diameter in the telescopic anastomosis group at 1 year postoperatively was 3 mm less than the preoperative measurements and remained steady at follow-up. Although the continuous anastomosis group had a decreased root diameter at 1 year, these patients had a higher rate of root dilatation afterward, at a rate of approximately 0.35 mm/year. As a result, the difference between the 2 groups in the percentage of patients with preoperative moderate aortic root dilation was even more significant (Figure 2, *B*). After 5 years, in the subgroup with preoperative aortic root diameter ≥40 mm, the mean diameter of the aortic root increased by 1.02 mm (95% CI, −0.28 to 2.31 mm) in the continuous anastomosis group, whereas the telescopic anastomosis group demonstrated a stable decrease in aortic root diameter (mean, 3.40 mm; 95% CI, 1.30-5.49 mm; $P < .001$).

Seven of the 60 patients (11.7%) in the continuous anastomosis group developed moderate or severe aortic insufficiency during follow-up, compared with 3 of the 38 patients (7.9%) in the telescopic anastomosis group. One patient (2.6%) in the telescopic anastomosis group developed an aortic root aneurysm necessitating reoperation at 1 year after the initial repair.

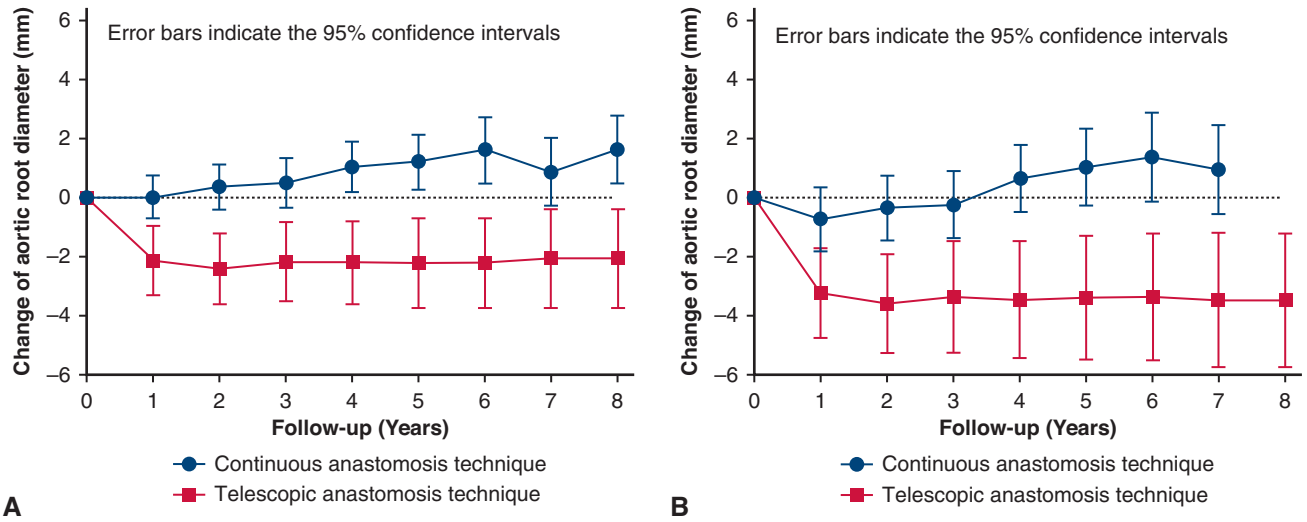

FIGURE 2. Generalized estimating equation analysis of the changes in aortic root diameter after surgical repair of acute type A aortic dissection with ascending aorta replacement during longitudinal follow-up in all study patients (A) and patients with initial aortic root diameter ≥40 mm (B). The changes in aortic root diameter differed significantly ($P < .05$ for all) between the different anastomosis groups in each year during the follow-up period both for all patients and for patients with preoperative moderate aortic root dilation.

No interventions were performed in the continuous anastomosis group. There was no between-group difference in the overall survival rate at medium term ($P = .391$) (Figure 3, *A*), in which the estimated 5-year survival rate was 82.6 ± 5.6% in the telescopic anastomosis group and 87.9 ± 4.0% in the continuous anastomosis group. Among the patients who survived until hospital discharge, the aortic root adverse event–free survival rate at 5 years was 93.5 ± 4.4% for the telescopic anastomosis group and 87.7 ± 4.8% for the continuous anastomosis group, and there was a trend toward better medium-term aortic root adverse event–free survival rate in the telescopic anastomosis group ($P = .081$) (Figure 3, *B*).

DISCUSSION

We have demonstrated that telescopic and continuous anastomosis during aTAAD repair achieved good and comparable results in the short term in selected patients not requiring root replacement. Although telescopic anastomosis is associated with a longer CPB time, the choice of technique was not an independent factor related to in-hospital mortality or morbidities. Standardized approaches to aTAAD, such as perfusion strategy, indications for the extent of aortic replacement, and associated hybrid procedures, have been established in both hospitals participating in this study. We believe that these standardizations contribute to the consistency of our short-term outcomes, which are not affected by the modification of the surgical procedure and minimize possible detrimental effects of the longer CPB time associated with the use of telescopic anastomosis technique. However, because prolonged CPB time is a known risk factor for unfavorable early outcomes,[3,4] the decision to perform time-consuming telescopic anastomosis in patients with aTAAD who required and have undergone more complex distal aortic procedures or concomitant intracardiac procedures should be made judiciously. Although we did find a higher number of reexplorations in the telescopic anastomosis group, the difference was not statistically significant. Furthermore, none of the patients who required reexploration had surgical bleeding. A possible explanation for this higher rate of reexploration could be the more significant coagulopathy due to the longer CPB times in the telescopic group, although we did not perform comprehensive post-bypass coagulation function analysis in these patients to confirm this presumption. The priorities in surgical repair of aTAAD are maximizing patient survival and minimizing operative complications. Thus, we emphasize that modifications to existing surgical procedures should depend on the surgeon's experience and confidence. This is especially true when a complex distal arch reconstruction is necessary.[4,19]

Along with previous studies, our results show that in patients without indications for root replacement during aTAAD repair, ascending aorta replacement with anastomosis at the level of the sinotubular junction (ie, supracommissural anastomosis) could provide favorable outcomes with a low incidence of reintervention.[5-13] The indications for aortic root replacement are standardized in our institution and include intimal tears within the aortic root

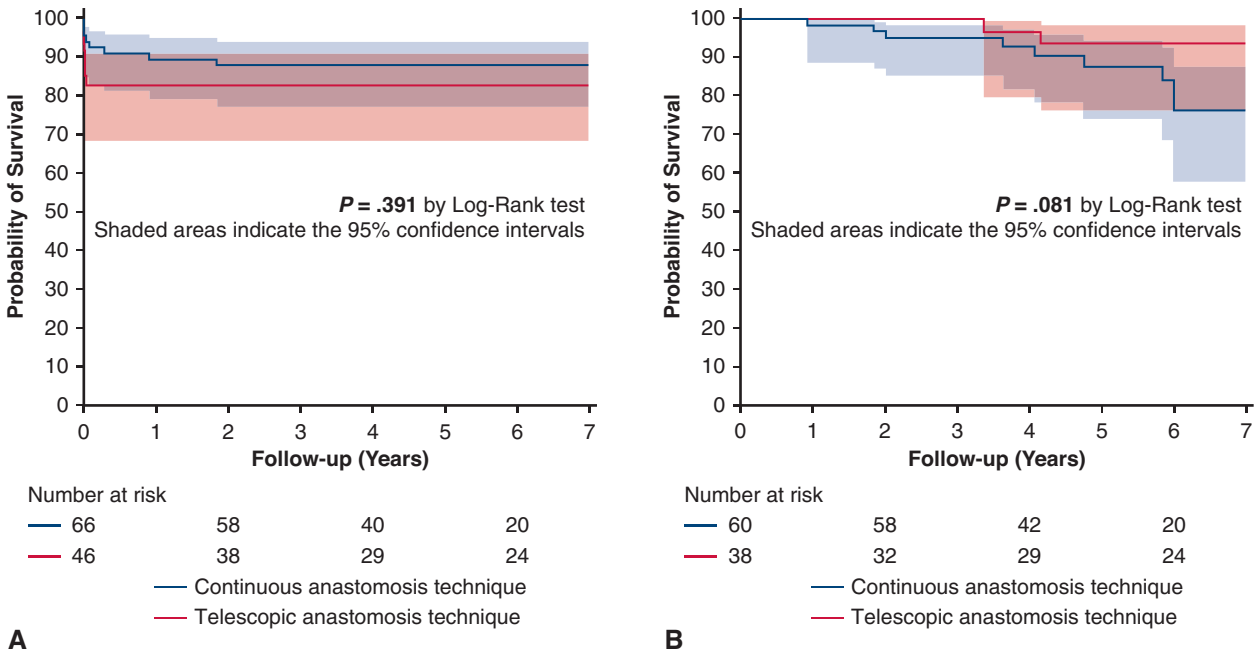

FIGURE 3. Kaplan–Meier survival curves of overall survival of all patients (A) and aortic root adverse event–free survival of patients who survived to hospital discharge after initial acute type A aortic dissection repair (B). The survival curves are truncated when fewer than 10 patients at risk remain in either group.

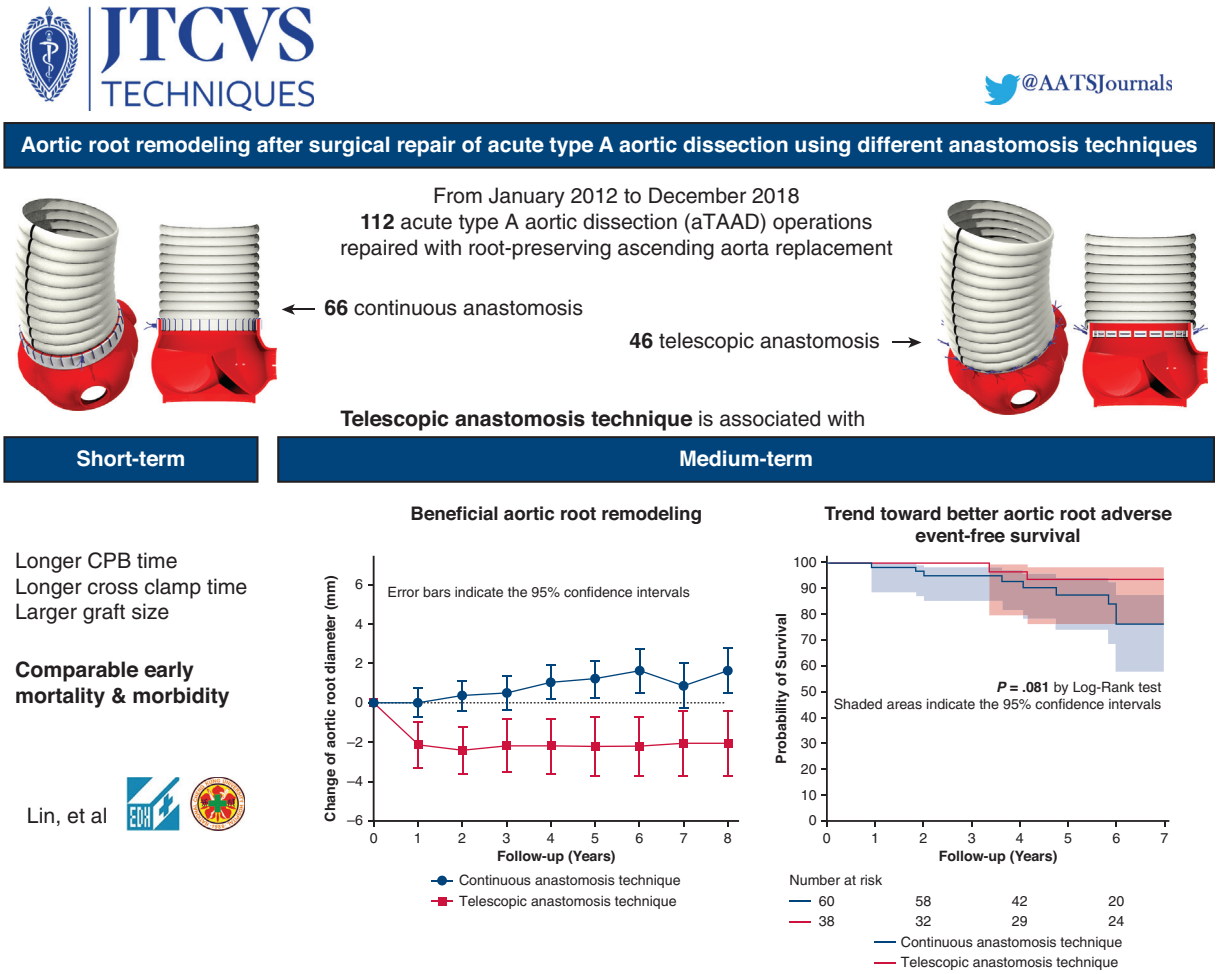

FIGURE 4. Compared to the continuous anastomosis technique, the telescopic anastomosis technique used for proximal supracommissural anastomosis in acute type A aortic dissection repair has comparable early outcomes, beneficial aortic root remodeling, and a trend toward better aortic root adverse event–free survival in the medium term. *CPB*, Cardiopulmonary bypass.

and an aortic root diameter ≥50 mm. For most aTAAD patients with aortic valve insufficiency, ascending aorta replacement with valve resuspension can restore the competent aortic valve. In patients with existing aortic valve pathologies that are unrepairable but not associated with new-onset dissection, aortic valve and ascending aorta replacement can be an alternative to the replacement of the entire root. Although controversies remain, aggressive root replacement has been advocated for those with extensive dissected aortic roots, specifically for those with more than 2 sinuses of Valsalva.[20] Notably, the extent of the sinus of Valsalva involved in the dissection flap is not an indication for aortic root replacement in our practice. We routinely use a modified sandwich technique to obliterate the false lumen before graft interposition during aTAAD repair, regardless of anastomosis technique. Residual aortic root dissection or pseudoaneurysm formation was not observed following the use of this approach. However, the aortic root was replaced in some patients because of weak aortic tissue at the sinotubular junction, which made anastomosis difficult. Conversion to root replacement after the initial attempt at ascending aorta replacement also occurred. In both these situations, the patients did not meet the standard indication for but underwent root replacement eventually, and they were not included in this analysis.

Despite the low incidence of reintervention for the aortic valve or root in both groups in the medium term, our results show preferable aortic root remodeling after root-preserving aTAAD repair using the telescopic anastomosis technique. In the telescopic anastomosis group, a decrease in root diameter was observed within the first year after surgery, and this decrease remained stable during follow-up. In contrast, progressive dilation of the aortic root was found in the continuous anastomosis group. Nonetheless, the rate of dilation was only 0.2 mm/year, similar to that reported in previous studies.[21-23] The telescopic anastomosis technique also was associated with a trend toward a decreased incidence of moderate or severe aortic

insufficiency during follow-up. These findings were more apparent in patients with moderately dilated aortic roots (≥40 mm). Previous studies have shown that preoperative root diameter may be the most crucial risk factor for postoperative aortic root dilation, aortic insufficiency, and reintervention. Thus, the use of the telescopic anastomosis technique could be a more valid option in aTAAD repair in patients with existing moderate root dilation with no absolute indication for aortic root replacement.[24]

We propose some hypotheses to explain the beneficial effect of the telescopic anastomosis technique for aTAAD repair. First, using the telescopic anastomosis technique, the vascular graft was "parachuted" down and placed outside the aorta at the level of the sinotubular junction. The graft surrounding the aorta may not only directly downsize the sinotubular junction, but also have a stabilizing effect that prevents the progression of aortic root dilation and aortic valve regurgitation, similar to the ring placed at the sinotubular junction when managing aortic insufficiency associated with ascending aortic dilation. Second, compared to continuous sutures, interrupted mattress sutures may serve as a buffer or cushion against the radial force generated by heart contractions. Nevertheless, the abovementioned standpoints are all speculative, as we did not obtain aortic root tissue for histopathologic examination because reoperation was performed only rarely. Additionally, although larger grafts were used in the telescopic anastomosis group compared with the continuous anastomosis group, we found that graft size itself was not associated with any difference in postoperative aortic root diameter change. Further simulated hemodynamic studies may help determine whether graft size has an impact on root remodeling after surgical repair of aTAAD.

Limitations

The major limitations of this study include the limited number of cases and the relatively low incidence of aortic root–related adverse events during follow-up. The collection of more aTAAD surgical cases performed with the telescopic anostosis technique with longer follow-up is needed to provide stronger evidence supporting the beneficial effect of late aortic root remodeling. Surveillance for connective tissue disease was not routinely conducted in the aTAAD patients in our study. Additionally, preoperative echocardiography was not comprehensive for every patient in the emergency setting, which might have led to us missing in some possible variables associated with late aortic root dilation or aneurysmal formation in this retrospective study.

CONCLUSIONS

The telescopic anastomosis technique is a safe alternative to the conventional continuous anastomosis technique for surgical repair of aTAAD. Despite longer CPB and aortic cross-clamp times, the telescopic anastomosis technique was not associated with increased early adverse outcomes. In the medium term, the incidence of adverse outcomes of the aortic root, such as reoperation, aneurysmal dilatation, or significant aortic insufficiency, was low in both groups. Compared to continuous anastomosis, telescopic anastomosis results in beneficial aortic root remodeling in the medium term by preventing progressive aortic root dilation following aTAAD repair during follow-up (Figure 4).

Conflict of Interest Statement

The authors reported no conflicts of interest.

The *Journal* policy requires editors and reviewers to disclose conflicts of interest and to decline handling or reviewing manuscripts for which they may have a conflict of interest. The editors and reviewers of this article have no conflicts of interest.

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