Chordal Translocation: Secondary Chordal Cutting in Conjunction with Artificial Chordae for Preserving Valvular-Ventricular Interaction in the Treatment of Functional Mitral Regurgitation

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Functional mitral regurgitation (FMR), a serious complication related to dilated cardiomyopathy, is associated with increased mortality, irrespective of whether an underlying left ventricular dysfunction is present. FMR with mitral leaflet tethering can be improved by secondary chordal cutting, the technique may compromise valvular-ventricular interaction. The aim of chordal translocation (CT) is to maintain valvular-ventricular interaction.

Methods: An initial successful mitral valve repair with CT was performed on a 55-year-old patient with FMR. Following secondary chordal cutting, artificial chordae were sutured to the tip of each papillary muscle, from where the secondary chordae originated. The artificial chordae were passed through the mid-septal annulus and fixed on the side of the left atrium. The force direction generated by the artificial chordae was very similar to the natural stress line on the anterior mitral leaflet. In a subsequent clinical series, CT was performed on 13 FMR patients.

Results and Conclusion: The study results indicated that CT, in conjunction with secondary chordal cutting, might represent a promising treatment for preserving valvular-ventricular interaction in FMR patients.

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Clinical material and methods

Preliminary study

A 55-year-old man presenting with ischemic cardiomyopathy associated with FMR was admitted to the authors’ institution. Seven years previously, he had undergone coronary artery bypass grafting (CABG) (left internal thoracic artery to left descending artery, aorta to first obtuse marginal branch by saphenous vein) for chronic myocardial infarction of the anterior and lateral walls. However, even after the surgery, the symptoms of both cardiomyopathy and heart failure had progressively worsened. Echocardiography revealed a left ventricular ejection fraction (LVEF) of 27% with moderate mitral regurgitation (MR), and severe hypokinesis of the anterior and lateral walls. The ‘tethering height’ - that is, the distance between the leaflet coaptation site and the annular plane - was also measured. A characteristic distraction was observed on the anterior mitral leaflet, which was tethered by the secondary chordae (tethering height 10 mm) to form a bend, thereby reducing the area of the coapting surface. Preoperative coronary angiography revealed no progression of coronary arterial stenosis or restenosis at the site of the CABG.

At surgery, a median sternotomy was performed, followed by mitral valve repair and CABG. The right internal thoracic artery (RITA) and gastroepiploic artery (GEA) were harvested. During cardiopulmonary bypass (CPB) with cardiac arrest, the mitral valve was exposed via a right-sided left atriotomy, and the tips of each papillary muscle and the anterior mitral annulus were examined. Although both mitral leaflets appeared normal, the anterior mitral leaflet

Figure 1: An intraoperative view through right-sided atriotomy. The artificial chordae are placed by anchoring in each papillary muscle tip, and are then passed through the saddle horn.

Figure 2: Schematic representation of chordal translocation with chordal cutting. A) Mitral regurgitation arises from tethering of the anterior leaflet. B) Chordal translocation was carried out after secondary chordal cutting. A valve: Aortic valve; M valve: Mitral valve.
was lifted to identify the secondary chordae beneath it. Both of the secondary chordae, which exert a force on the body of the anterior mitral leaflet, were severed as secondary chordal cutting. A 5-0 Teflon-pledgeted polytetrafluoroethylene suture was used as an artificial chordae; this was sutured to the tip of each papillary muscle, from where the secondary chordae originated. The artificial chordae were passed through the saddle horn and fixed on the side of the left atrium (Figs. 1 and 2), with care being taken to avoid damage to the aortic cusps. The length of the artificial chordae was adjusted such that excessive tension did not develop at each papillary muscle tip, and the chordae appeared straight with minimum tension (i.e., taut) in the operative field. The distances between the trigones of the mitral annulus were measured using a sizer, and the mitral annuloplasty was performed by using a 25-mm flexible ring and 2-0 Tycron interrupted mattress sutures. Furthermore, CABG (aorta to intermediate branch by RITA free graft, GEA to second obtuse marginal branch via posterolateral branch as a sequence) was performed. After weaning the patient from CPB, intraoperative transesophageal echocardiography confirmed the improvement in MR following tethering of the anterior mitral leaflet.

The patient experienced an uneventful recovery, with postoperative echocardiography revealing trivial MR, an improvement in the leaflet tethering (tethering height 3 mm), no prolapse of the anterior mitral leaflet in spite of secondary chordal cutting, and an improvement in the LVEF (to 42%).

Clinical series
Between September 2004 and August 2006, 13 patients (nine males, four females; mean age 61 ± 9 years) with FMR caused by ischemic or idiopathic cardiomyopathy were treated using the above-described technique. The preoperative and postoperative data of the patients are summarized in Table I. The mean preoperative MR grade, tethering height and LVEF were 2.9 ± 0.7, 10 ± 1.4 mm and 26 ± 14%, respectively. Mitral annuloplasty was performed on all patients by using an undersized flexible or semi-rigid ring (24-27 mm). In addition, CABG (n = 6), tricuspid annuloplasty (n = 6) and surgical ventricular restoration (n = 5) were performed.

There was no operative mortality. Postoperatively, the MR grade was reduced to 0.7 ± 0.4 (p <0.001 versus preoperative value, as determined by the Wilcoxon single-rank test), and the tethering height was markedly decreased to 3.8 ± 0.8 mm (p <0.001 versus preoperative value). The postoperative LVEF was 42 ± 14% (p <0.001 versus preoperative value). Although a suture made at the saddle horn may have caused aortic regurgitation if the non-coronary aortic cusp was involved, this did not occur in any of the 13 cases.

The mean follow up period was 19 months, during which time three patients died due to aneurysm of a...
Cerebral vessel, refractory ventricular arrhythmias, and heart failure despite the absence of MR; the three deaths occurred at six, six and 17 months after surgery, respectively. A fourth patient died suddenly, of unknown cause, at 25 months after surgery. This relatively high rate of late mortality may have been attributed to the fact that, preoperatively, the general condition of the patients was poor, or their cardiac reserve was too small.

Discussion

It is well known that mitral valvular-ventricular interaction is important for maintaining left ventricular systolic function (7). In particular, the secondary chordae - the large chordae that are inserted to the anterior mitral leaflet - play an important role in preserving valvular-ventricular interaction. Although secondary chordal cutting is commonly used to treat FMR, and can also improve mitral valve tethering, it may compromise the valvular-ventricular interaction. In the past, the status of left ventricular systolic function following secondary chordal cutting has been considered controversial. For example, Messas et al. reported that the left ventricular function was maintained following secondary chordal cutting in a normal ovine model (10). In contrast, Rodriguez et al. noted that secondary chordal cutting altered the left ventricular geometry and impaired the left ventricular systolic function (7). Furthermore, He and Jowers indicated that secondary chordal cutting would lead to increased tension in the marginal chordae and might ultimately affect mitral valve function, and thus left ventricular function (11). Therefore, by maintaining valvular-ventricular interaction, the secondary chordae may play an important role in left ventricular systolic function.

The aim of CT is to restore any valvular-ventricular interaction that may have been compromised by secondary chordal cutting. The force direction generated by the artificial chordae in CT is very similar to the natural direction, as indicated by the stress line on the anterior leaflet (which extends from the secondary chordal insertion to the anterior mitral annulus). In the present study, CT might become a preferred modality for treating FMR, as it can ameliorate severe tethering and maintain valvular-ventricular interaction while preventing the development of excessive tension in the papillary muscles (by maintaining a constant distance between the papillary muscles and the mid-septal mitral annulus).

The efficacy and shortcomings of this novel method have been reported previously, using a canine animal model, when it was found that the tension in the artificial chordae should be minimal (i.e., no excessive tension) (8,9). The other internal-repositioning techniques, as described above, might be singularly effective for the treatment of FMR; however, suturing the papillary muscle tip might cause excessive tension in the chordae (12). In order to avoid this situation, the length of the artificial chordae used in CT is adjusted such that they appear straight with minimum tension (i.e., taut) in the operative field. Experience gathered from experimental series has suggested that, if the chordae experience excessive tension, then the systolic function will not improve and the diastolic function will be impaired; this may in time lead to ventricular arrhythmias or papillary muscle rupture (9).

As IMR is a ventricular disease - that is, it not only a valvular disease - surgical ventricular restoration, if indicated, may be the treatment of choice. However, if such an approach is not feasible, then alternative techniques related to the left ventricular geometry without damaging the left ventricle should be considered. Left ventricular remodeling should also be carefully considered in the future. Based on the above viewpoints, CT may represent a good choice, as it can ameliorate the severe tethering and eliminate the need for left ventricular remodeling. Moreover, surgical ventricular restoration will not be necessary because CT can maintain the valvular-ventricular continuity, with no excessive tension in the papillary muscles; that is, a constant distance is maintained between the papillary muscles and the mid-septal mitral annulus.

Study limitations

The primary limitation of the study was that the samples were highly heterogeneous, and the population and period of follow up were extremely small. The improvements in left ventricular function might also have been affected by other procedures. However, Rodriguez et al. have suggested previously that left ventricular function would be worsened after secondary chordal cutting in an acute ovine IMR model, because of a decrease in the preload recruitable stroke work (7).

In conclusion, the aim of chordal cutting is to decrease anterior leaflet tethering at the cost of left ventricular systolic geometry and/or function. In these pilot studies, CT - when used in conjunction with secondary chordal cutting - might represent a promising technique for preserving valvular-ventricular interaction in FMR patients. However, additional investigations will be required to verify these claims.
References


