leaflet where the neochordae are inserted can be described by means of 2 Lagrangian parameters governing the deformation of the beam, which are the end-point angle θ_l and the force inclination α (Figure 1). As a matter of fact, the angle α is determined by the orientation of the chorda tendinea and depends on both the angle θ_l and the position of the papillary muscle. Other factors that require considerations are material constants, which can be modeled by the tensile Cauchy stress σ and by Piola-Kirchhoff nominal stress and represent the edge load per unit reference cross-sectional area of the neochordae. Material constants are important, because the insertion of neochordae occur on degenerated leaflets and tissues that are composed of a different mechanical resistance than a normal leaflet.

In conclusion, we congratulate Yoshida and colleagues² and Padala¹ for their work. We believe that a model taking into account not only geometric but also biomechanical and functional dynamic parameters is of paramount importance to our exhaustive understanding of the issues relative to degenerative mitral disease.

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IS INDIVIDUALIZED MITRAL VALVE REPAIR IN THE FUTURE?

Reply to the Editor:

We appreciated the editorial commentary¹ by Dr Padala on our study² and enjoyed reading the letter to the Editor, “Euler’s Elastica-Based Biomechanical Assessment for Neochordal Insertion in the Treatment of Degenerative Mitral Valve Repair” by Nappi and colleagues.³

We agree with Padala¹ and Nappi and colleagues³ that both the morphologic and biomechanical characteristics of the mitral leaflets are important in the treatment of mitral regurgitation (MR).^{1,3} Although the biomechanics of the subvalvular apparatus have been discussed in the *Journal* as a pivotal mechanism in ischemic MR,³ we focused on the detailed morphologic evaluation of the leaflets and subvalvular apparatus in patients with degenerative MR to achieve precise and individualized mitral repair.² When performing a morphologic evaluation, electrocardiogram (ECG)-gated computed tomography (CT) exquisitely displays dynamic cardiac anatomy at any phase. Subsequent to the introduction of transcatheter aortic valve implantation, preoperative evaluation of the aortic annulus, sinus of Valsalva, and coronary artery orifices has been performed using ECG-gated CT. We used this technology for evaluation of the valvular and subvalvular geometry of the mitral valve. In contrast to evaluation of the aortic root, evaluation of the mitral leaflets is difficult because

FIGURE 1. Mitral valve configuration after repair surgery using reconstruction with artificial chordae precisely measured using 320-slice CT in a patient with normal mitral leaflets and torn chordae (left) and a patient with more elastic or redundant leaflets (right).

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they are thinner and move rapidly. However, evaluation of the mitral leaflets is possible in the midsystolic phase when there is minimum movement. In addition, evaluation of the papillary muscles using ECG-gated CT is more useful than echocardiographic evaluation because the number and size of the papillary muscles remain obscure on an echocardiogram.⁴

Although our study demonstrated precise and dynamic morphologies of the mitral leaflets and subvalvular apparatus, assessment of biomechanical characteristics of the mitral valve may become more important for understanding mitral valve disease and developing new surgical treatments. In particular, elucidation of differences in elastic behavior between degenerated and normal leaflets may become an important target of mitral valve repair. More elastic mitral leaflets in extensive degenerative regions may require intraoperative adjustment to correct the length of artificial chordae,⁵ even though the distance between the tips of the papillary muscles and the normal leaflets is precisely measured with our technique using 320-slice CT because of redundancy and the different elasticity of mitral valve tissue in degenerative regions (Figure 1). This redundancy and different elasticity may cause difficulty in accurate length assessment of artificial chordae.

We expect that the biomechanical assessment proposed by Nappi and colleagues³ will allow us to achieve more precise and individualized estimation of the length of artificial chordae in degenerative tissue with different elasticity.

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PATIENT-SPECIFIC COMPUTATIONAL BIOMECHANICAL MODELING TO GUIDE MITRAL VALVE REPAIR STRATEGY: PRACTICALITY AND VALUE?

Reply to the Editor:

Finite element modeling (FEM) emerged in the 1950s from the work conducted by Jonathan Turner at Boeing Corporation. He developed the direct stiffness method and the first continuum-based finite elements for application to nonlinear problems. These seminal contributions were refined and later applied toward investigating structural mechanics in the aerospace industry, civil engineering, and machinery to reduce the burden of expensive experiments and decrease the design cycle time. Today, FEM modeling has become the standard in designing structures and optimizing material selection to ensure a robust design. In the past 2 decades, improvements in computational power and biomedical imaging have led to the application of FEM modeling to study the stresses on load-bearing structures in the human body (ie, heart valves, myocardium, blood vessels, knees, lungs) to correlate with the underlying biology. Mechanobiology, that is, the link between mechanics and biology, is now a thriving field with applications not only in cardiovascular disease but also in cancer therapeutics.

Nappi and colleagues¹ present a reasonable argument that FEM modeling can be applied in a patient-specific manner for planning heart valve repairs, in this case mitral valve repair for degenerative valve disease. Availability of 3-dimensional echocardiography data, with excellent spatial resolution and adequate temporal resolution, enables segmentation of the dynamic valve structure throughout the cardiac cycle and computation of temporal changes in the tissue stresses. The virtual nature of this platform also allows evaluation of a variety of surgical techniques on the dynamic valve model before implementing in the patient. The ability to iterate and optimize a surgery in this manner is appealing and could theoretically help in refining the repair for better biomechanics and ultimately better outcomes. In this specific communication, Nappi and colleagues¹ report a biomechanical model for the mitral valve, considering the chordae tendineae as 1-dimensional elements with Fung nonlinear elastic behavior and the leaflets as nonlinear parallel cantilever beams with end-point