

Adjustment of Artificial Chordae to the Mitral Valve with Advanced Tactile Technique

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Abstract

The precise determination of the length of artificial chordae and coevally the gental fixation of the defined length of the chordae on the mitral valve remains a challenge especially for the minimally invasive working heart surgeon. Methods to secure the correct length of the artificial chordae have been presented in the past either with the pean clamp or the more convenient but more breakable method with the hemoclip. Here the hemoclip-method is tested in an ameliorated tactile technique to advance the security for the patient.

1. Introduction

Implanting expanded polytetrafluoroethylene (ePTFE) neochordae is an established technique in treating complex mitral regurgitation. The most difficult aspect of chordal replacement in a mitral valve repair using expanded polytetrafluoroethylene sutures (fig. 1), is determining the appropriate length of artificial chorda and ligation of the ePTFE sutures without the knot sliding. Several techniques are described to evaluate the correct length [1,2] and to fix the defined length [3,4]. Difficulties in fixing the ideal neochordae length either with only knots or hemoclip and knots, led us to evaluate a method that allows a defined clip-force to ensure and fix the correct chorda length without weakening and damaging the neochorda.

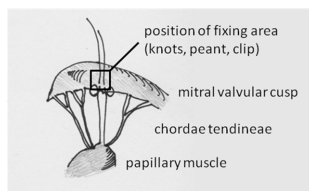


Figure 1. Chordal replacement in a mitral valve repair using expanded polytetrafluoroethylene (ePTFE) sutures. The fixing area of knots and clips for chorda replacement is marked.

2. Methods

A total of 70 ePTFE 4-0 sutures have been tested in 7 groups. One surgeon tied 10 knots in every surgical thread to fix the artificial chordae by bare hand, with and without surgical knot pusher device as control group respectively; the length of the neochorda was fixed by pean or by hemoclip, each with patch or without patch. The modification in the groups with hemoclip was an either surgical (90N) or an absolutely strong clamping force (210N) of the hemoclips. The hemoclip gripper was applied with strain gauge sensors. In the experiment the knotted surgical threads have been fixed between two robot arms (Mitsubishi) with force sensors testing the break force of each suture (fig. 2 and 3).



Figure 2. Two robot arms (Mitsubishi) with force sensors measuring the break force of each suture.

The applied and maximum forces were recorded taking the measuring points of the moving robot arm every 7 milliseconds.

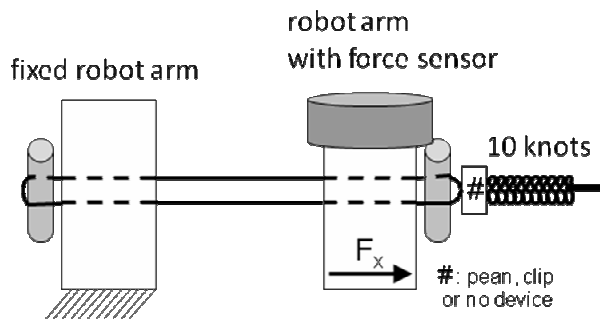


Figure 3. Schematic draft of the experimental set-up.

3. Results

The sutures knotted by hand and knotted by knot-pusher don't show a significant difference in breaking force. The pean clamp does not harm the suture significantly. Patches enforce the stability of surgical sutures. The strongly clipped hemoclip (fig. 4) weakens the suture significantly (F_{max} mean 27,25N; $p < 0,05$).

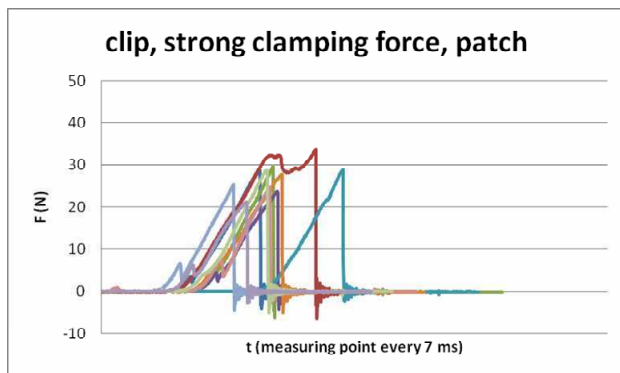


Figure 4. Strongly clipped hemoclip weakens the suture significantly (F_{max} mean 27,25N).

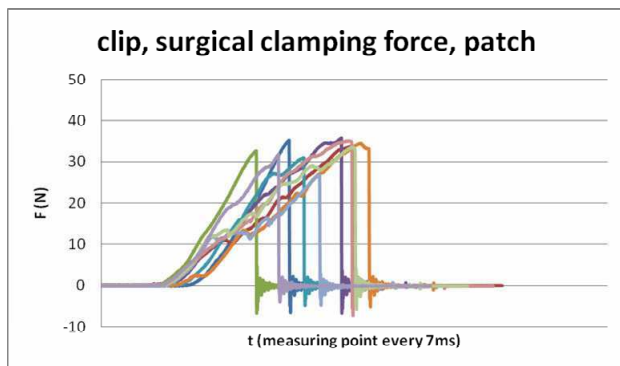


Figure 5. Clips applied with tactile surgical feedback the mean maximum breaking point is significantly higher (F_{max} mean 33,04N).

Using clips applied with tactile surgical feedback (fig. 5) the mean maximum breaking point is significantly higher (F_{max} mean 33,04N; $p < 0,05$).

Three surgical threads with strong clamping force broke before fixing in the robot arms. In the surgical clamping force group 6 threads expanded slowly before breaking.

4. Discussion and conclusions

In the future a clip gripper measuring the contact pressure online and evaluating a defined force feedback has to be designed for safety reasons for the patients.

This force-measured clip-method is a simple, safe and easy technique to ensure the correct length of artificial chordae in mitral valve repair. The haptic clip- technique to fix the adjusted artificial chordae can be used for artificial chordae-procedures without damaging the surgical thread to avoid complications and for best results.

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References

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