Augmented reality guidance for beating heart mitral valve repair: the NeoNav platform

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Mitral valve (MV) repair is a common treatment for degenerative mitral valve disease, a condition that affects 2% of the general population [1]. However, this treatment traditionally requires placing the patient on cardiopulmonary bypass, a procedure that is not always safe for patients with co-morbidities. Recently, devices have emerged that are capable of treating MV disease while the heart is still beating. One of these, the NeoChord DS 1000 (NeoChord Inc., Minnetonka, MN), relies exclusively on trans-esophageal echocardiography (TEE) for image guidance of the repair procedure [2]. The imaging protocol requires the echocardiographer to maintain a 2D bi-plane echo image on both the surgical target (MV line of coaptation) and the surgical tool, a non-trivial task requiring extensive training for both the echocardiographer and the cardiac surgeon. Our goal is to provide a more intuitive image guidance platform that facilitates navigation of intracardiac tools for MV repair.

Methods: The NeoNav image guidance platform integrates a magnetic tracking system (Aurora Tabletop, Northern Digital Inc., Waterloo, ON) with both surgical tools and TEE probe. In this manner we are able to present real-time TEE data with geometric models of the pertinent anatomy and the DS 1000 device (Fig 1a). This augmented reality environment makes it possible for surgeons to plan an optimal trajectory for the tool from an apical access point to the target MV anatomy.

![Figure 1](image-url)

Figure 1: (a) The NeoNav interface, showing mitral (red) and aortic (blue) valve annuli, DS1000 tool (green) and TEE probe with echo image data (grey). (b) Valve annuli with tool path data for one surgeon represented in green (echo) vs NeoNav (black) guidance. (c) Table showing results from two animal studies (n = 12 for echo, n = 10 for NeoNav).

In a randomized trial over two animal studies, six cardiac surgeons compared the use of echo-only guidance to the NeoNav guidance platform as a means of navigating the NeoChord DS1000 from the apex of the heart to the MV line of coaptation. Tool tip locations were tracked with the MTS, recording path length, tool tip distance from the midline, and total procedure time.

Results and Conclusions: Mean error distance from midline decreased by a factor of 3, completion time by 5 and path length by a factor of 5. A statistically significant level of improvement was identified in all tests (Fig 1c). Currently, patient safety is assured through the use of experienced proctors with extensive experience performing MV repair. The NeoNav platform will make it possible for this new surgical technique to be easily and quickly adopted by cardiac surgeons.

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