PRESS RELEASE

Assistance system for heart valve repair

Heart valve reconstruction is a highly complex operation that requires a great deal of expertise from surgeons. On the occasion of World Heart Day on September 29, 2024, the Fraunhofer Institute for Digital Medicine MEVIS will present the MINIMAKI assistance system. Based on artificial intelligence methods, it enables interdisciplinary cardiac teams from surgery, cardiology and anesthesia to plan heart valve procedures quickly and optimally using mixed reality.

According to the "Herzbericht der Deutschen Herzstiftung Update 2024" (Heart Report of the German Heart Foundation Update 2024), heart failure is the most frequent reason for hospitalization in Germany and one of the ten most common causes of death. It is often caused by a leaking heart valve. If the mitral valve, which regulates the flow of blood from the lungs to the heart, does not close properly, a minimally invasive procedure or surgery has to be performed. Valve replacement is associated with health risks, however. For this reason, heart surgeons prefer to repair the body's own valve. In many specialized centers, minimally invasive endoscopic surgery and catheter-based procedures have become established.

The mitral valve functions like an automatic two-leaf garage door. Its two valve leaflets open and close synchronously, and what are known as tendinous cords prevent them from falling into the cavity. If these cords are torn off or the leaflets or surrounding tissue are overstretched, the mitral valve will not close completely. Blood will then flow backwards when the heart muscle contracts. For the mitral valve to close tightly again, the two valve leaflets have to be brought closer together when they close. Heart surgeons achieve this by sewing in special rings or placing a clip between the two valve leaflets, for example. It is also possible to replace tendinous cords.

Simulation on a digital twin

Heart valve repair is a highly complex procedure that requires a great deal of expertise. "Procedures are performed under time pressure, which is why precise treatment planning is very important," explains Fraunhofer researcher Dr. Anja Hennemuth, a professor at the Institute of Cardiovascular Computer-assisted Medicine (ICM) at Deutsches Herzzentrum der Charité. The MINIMAKI assistance system, which was developed at the Fraunhofer Institute for Digital Medicine MEVIS in cooperation with Deutsches Herzzentrum der Charité and the software company data experts gmbh, supports cardiac teams in planning operations at a PC and enables interactive simulation of the

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procedure on a digital twin. This makes it possible to try out different strategies for the procedure or to find the most suitable implant for the valve reconstruction. In addition to ring implantation, MINIMAKI can simulate a tendinous cord replacement and transcatheter-edge-to-edge-repairs (TEER).

Dynamic model of a patient's heart

The system can be connected to various imaging modalities such as cardiac ultrasound, CT or MRI scanners. Machine learning algorithms analyze the 4D image data set and transfer the data to the dynamic model, which — in addition to providing a spatial representation of the individual patient's heart — three-dimensionally displays the heart, the contraction of the heart muscle, the movement of the valve leaflets and the flow of blood. Doctors can use mixed reality to place potential replacement parts over the patient model. The system shows doctors all the parameters that they need for their planning. "Heart surgeons get more than just a feel for what the repair site looks like," says Prof. Jörg Kempfert, a senior consultant for cardiac surgery at Deutsches Herzzentrum der Charité. "They also get quantitative information that helps them choose the best implant," he adds. Heart surgeons have access to a digital device library containing information on all relevant commercially available implants in all available sizes. For this purpose, Fraunhofer researchers have created high-resolution CT scans of all implants.

Discussions at the hologram

Before an operation, MINIMAKI enables discussion within the cardiac team as well as the involvement of heart specialists via the internet. This discussion can take place using a desktop application on a monitor and can incorporate a virtual 3D model with which all team members can interact. Since wearing VR glasses would hinder discussion, MINIMAKI uses a mixed reality environment. The hologram in the middle of the room allows team members to view the anatomy of the heart in three dimensions and from all angles, and to rotate the virtual heart as desired.

The system is also suitable for teaching and training young doctors. With MINIMAKI, it is hoped that younger surgeons will be able to learn the procedures involved in repairing and maintaining the body's own heart valves more quickly and easily. "In many cases, the only reason why heart valves are replaced is that doctors are unable to repair them or feel unsure," notes Kempfert. "We hope that MINIMAKI will help to improve quality so that even more heart valves can be repaired instead of replaced."

The Fraunhofer Institute for Digital Medicine MEVIS (collaboration coordinator) and the partners Deutsches Herzzentrum der Charité and data experts gmbh were involved in the MINIMAKI project. The project ran for three years and received funding of 2.1

million euros, 86% of which was covered by the German Federal Ministry of Education and Research (BMBF).

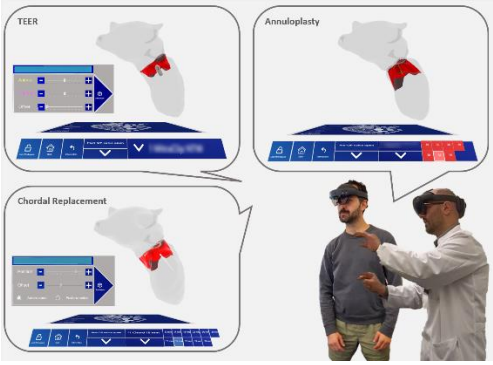

Fig. 1 MINIMAKI enables patient education and planning of heart valve procedures using Mixed Reality. Therapy options can be selected virtually, and the use of a suitable implant can be simulated.

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Embedded in a network of clinical and academic partners**, Fraunhofer MEVIS** develops practice-oriented software solutions for image- and data-based early detection, diagnosis and therapy. The focus is on cancer and diseases of the cardiovascular system, brain, breast, liver and lung. The goal is to detect diseases earlier and more reliably, tailor treatments to the individual and make therapeutic success measurable. In addition, the institute develops software systems for industry partners as a means of analyzing image-based studies on the effectiveness of drugs and contrast agents. To achieve its goals, Fraunhofer MEVIS works closely with medical technology and pharmaceutical companies, providing solutions for the entire innovation chain from applied research to certified medical devices.

The **Fraunhofer-Gesellschaft**, based in Germany, is a leading applied research organization. It plays a crucial role in the innovation process by prioritizing research in key future technologies and transferring its research findings to industry in order to strengthen Germany as a hub of industrial activity as well as for the benefit of society. Founded in 1949, the Fraunhofer-Gesellschaft currently operates 76 institutes and research units throughout Germany. Its nearly 32,000 employees, predominantly scientists and engineers, work with an annual business volume of 3.4 billion euros; 3.0 billion euros of this stems from contract research.