DEVELOPMENT OF MINIMALLY INVASIVE IMPLANTABLE AUTOLOGOUS TISSUE-ENGINEERED HERAT VALVE FOR CONGENITAL HEART DISEASE

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OBJECTIVE

In congenital heart disease (CHD), such as tetralogy of Fallot, artificial materials are commonly used to reconstruct blood vessels and heart valves. However, these materials deteriorate over time and often fail to function within a few years after surgery. As a result, patients who undergo heart valve surgery in childhood for CHD often require multiple reoperations, highlighting the need for alternative approaches to reduce the risks associated with open heart surgery. In this situation, transcatheter valve implantation has emerged as the preferred option. Our study focuses on the development of an autologous tissue-engineered prosthetic heart valve, named Biovalve, utilizing an "in body tissue architecture" approach [1, 2]. In this approach, a tissue-forming mold is implanted subcutaneously, and the connective tissue that forms around the mold serves as the implantation material. Biovalve is an autologous collagen tissue with high biocompatibility and tissue regeneration potential [3]. It is promising for CHD patients due to its potential for tissue regeneration and long-term valve function, offering a viable alternative to multiple surgical procedures. This study aims to develop Biovalves equipped with self-expandable stents, implant them in large animals using a transcatheter technique, and evaluate both their valve function and tissue structure.

METHODS

We utilized 3D printed plastic molds in conjunction with shape memory alloy stents, embedding them subcutaneously in goats. Following a period of 2-3 months, the molds were extracted along with the surrounding tissue. By removing the plastic components, we isolated heart valve-like tissues composed of autologous connective tissue (Biovalves) with integrated stents. Subsequently, the stent Biovalve was inserted into a delivery catheter and implanted into a goat pulmonary valve through the right ventricular apex.

RESULTS

Using a mold encapsulating the stent, we obtained a stent-integrated Biovalve in which the stent was covered with autologous tissue. Both the stents and Biovalve tissues exhibited strong adherence and remained securely in place even under crimping conditions. The Biovalves were successfully implanted with minimal complications, showing no significant stenosis or regurgitation. Despite the absence of anticoagulation therapy post-implantation, there were no findings of thrombosis. After 6 months of implantation, the Biovalve was harvested, and the valve leaflets had retained their morphology, with no thrombi observed on their surfaces. Furthermore, the Biovalves were integrated with the surrounding tissue. Histological examination revealed a gradual migration of host cells into the Biovalve tissue, indicating ongoing tissue remodeling.

CONCLUSIONS

The Biovalve with a stent can be implanted with minimal invasiveness, offering the potential for long-term functionality due to tissue regeneration post-implantation. This innovation holds promise for the treatment of CHD and presents an attractive alternative to traditional surgical interventions.

References

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Acknowledgments

This research was supported by AMED under Grant Number JP23he0422026.