



The man who made people smile

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_On December 20, 2014, Per-Ingvar Brånemark died after a period of extended illness in his hometown of Gothenburg, Sweden.

Without the work of Per-Ingvar Brånemark, the world might still be awaiting the advent of titanium implants. His observation, in the midtwentieth century, that the human body would not only tolerate titanium, but even integrate it into living bone tissue (under carefully controlled conditions) revolutionised the fields of dental, maxillofacial and orthopaedic rehabilitation. Based on his original scientific insight—subsequently substantiated and rigorously documented—innovative bone-anchored restorative solutions have improved the quality of millions of people's lives around the world since then.

_Choosing the right path

Students of science say that luck combined with unique circumstances often dictate the direction in which any research project ultimately turns. No one was more aware of this than Per-Ingvar Brånemark.

As a young researcher in his native Sweden in the 1950s, he was interested in neither titanium nor implants. He was working instead to advance the world's knowledge of the anatomy of blood flow, and found himself using an optical device that happened to be enclosed in machined titanium. Attached to a rabbit's leg, this device made it possible for him to study microcirculation in the bone tissue of rabbits through specially modified light microscopes. When it came time to re-

move the device from the bone, Brånemark was surprised to find that the bone and the titanium had become inseparable.

In a subsequent study of microcirculation, approximately 20 students who volunteered to have titanium instruments inserted into their arms for several months showed no signs of rejecting the titanium-enclosed optics. At that point, Brånemark changed the direction of his work to investigate the body's ability to tolerate titanium.

Breaking down borders

Seeing that the body could peacefully coexist with titanium, perhaps indefinitely, Brånemark wanted to find out the reasons why. He realised that he would need to approach this new area of research from several different perspectives simultaneously.

To gain a proper understanding of osseointegration—the term Brånemark coined for the integration of titanium into living bone tissue—he realised that one would need access to expertise in physics, chemistry and biology, at the very least. Under Brånemark's leadership, physicians, dentists and biologists would all investigate the interplay between bone and titanium. Together they developed careful, methodical techniques for the insertion of implants. At the same time, engineers, physicists and metallurgists studied the metal's surface and how the design of the implant might have an effect on bone healing and growth.

Meeting resistance

Brånemark found himself working in a headwind. His findings that the body would accept titanium over the long term, and even allow it to integrate in bone, flew in the face of conventional wisdom. In the mid-1960s, physicians and dentists were still being taught that foreign, non-biological materials could not be integrated into living tissue. Initial inflammation and ultimate rejection were considered to be inevitable.

Previous trials with implants had failed, after all, and caused patients considerable suffering. The academic world questioned Brånemark's research, partly because of the failures of others in the past and partly because he was working in so many different academic disciplines at the same time.

Funding from Swedish research organisations dried up. He was repeatedly turned down when he applied for renewed grants to study tissue anchored implants, yet he persevered. Eventually the US National Institute of Health stepped in and funded his research, which made it possible for him to repeatedly demonstrate the accuracy of his claims and the viability of osseointegration,

but it wasn't until the mid-1970s that the Swedish National Board of Health and Welfare were finally prepared to approve of the Brånemark method.

For the benefit of the patient

In 1965 a Swedish man, Gösta Larsson, became Per-Ingvar Brånemark's first dental implant patient. Using a very cautious method that his research group had devised to show the greatest possible degree of respect to the living bone tissue, Brånemark inserted a set of titanium implants that Larsson would have for the rest of his life.

This remarkable patient had been born with a deformed jaw, and the four titanium implants that he received that day meant that a set of new teeth could be attached to his jaw. For the first time in his life, he could eat and talk normally. When he died in 2006, his implants had worked without problems as the foundation for a series of oral prostheses for 40 years. Since then, well over ten million people worldwide have benefited from Per-Ingvar Brånemark's discovery. Both in Sweden and abroad, Per-Ingvar Brånemark's achievements in the field of osseointegration have opened up entire new areas of promising research.

Some Brånemark-inspired research teams now focus on trying to better understand how the processes of healing and immune defense interact. Others focus on the surface structure and chemistry of titanium implants, in attempts to tweak the surface properties just enough to give the body an even better chance for rapid and safe healing.

As the number of successfully treated patients explodes around the globe, yet other centres scientifically evaluate both new and well-established component designs to ensure that the highest possible standards of safety and efficacy continue to be maintained in the future. Per-Ingvar Brånemark's greatest legacy may be the fact that medical and dental schools now teach the use of osseointegrated implants as a routine part of their normal curricula.

The pursuit of learning for the sake of constant improvement was paramount in his professional life and reflected in this often repeated maxim: "We must never forget that from the patient's point of view, the criteria which differentiate between success and failure are always the key issues we face as a team."

