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Presentation highlights: Osseointegration

Robert Myers, PhD
San Diego Veterans Affairs Medical Center; University of California, San Diego

BIOGRAPHICAL INFORMATION

Dr. Robert Myers is a senior research career scientist in the Department of Veterans Affairs, San Diego Healthcare Center, as well as Professor of Anesthesiology and Pathology in the Division of Pathology at the University of California, San Diego (UCSD). He received his PhD in Bioengineering from the University of California, San Diego. He advanced in joint appointments between the Department of Veterans Affairs, San Diego Healthcare Center, and UCSD over the next 25 years to his present positions.

Dr. Myers is Editor-in-Chief of the *Journal of the Peripheral Nervous System*. His awards and honors encompass the Volvo Award for Low Back Pain Research, International Society for Study of the Lumbar Spine, 2000; Senator Jacob Javits Neuroscience Investigator, NIH, 1992–1999; Anesthesiology Specialist, Department of Veterans Affairs, Washington DC, 1994–1997; Nobel Biocare Lecturer, London, 1998; Lecturer, American Society of Regional Anesthesia, 1994; President and Chairman, Board of Directors, 1976–1979; and Member, Board of Directors and Professional Advisory Board, San Diego County Epilepsy Society, Inc., 1975–1993.

His research interests include:

- mechanisms of neuropathic pain,
- nerve blood flow,
- microcirculation,
- peripheral neuropathy,
- neurotoxicity,
- quantitative neuropathology,
- regeneration,
- bioengineering,
- orthopedics,
- osseointegration, and
- osseoperception.

PRESENTATION

Osseointegration is a phenomenon discovered in the 1950s by Swedish bioengineer Per-Ingvar Brånemark, who realized that after implanting titanium cylinders into the femurs of rabbits, he could not extract the titanium without destroying the surrounding bone. The discovery that bone will integrate with titanium components, not rejecting the element as it does other materials, was the beginning of the study of osseointegration.

Titanium is widely used in dental implants because of this inert property and is being used increasingly with limb prostheses, mainly in Europe. For above-knee amputees, a titanium bolt is inserted into the cavity of the femur, extending through the skin. After approximately six months, during which the bone integrates with the implant, a titanium extension is attached to the implant. The prosthesis then is attached to this extension, or abutment, via an Allen-head screw.

Direct skeletal attachments are only possible if practitioners respect the integrity and living nature of bone and use low-speed, low-heat drills. Titanium implants are specially designed high-strength devices and not merely “titanium screws.” A single titanium dental implant, only a few millimeters in diameter, can support up to 100 kg.

Titanium has already been used successfully in several patients. One amputee has had bilateral osseointegrated titanium fixtures for 11 years, with no complications. Titanium has also provided prostheses for an

Italian policeman who lost both legs in a car bomb explosion. In addition, several thumb prostheses with titanium interfaces are currently in use.

The process termed "osseoperception" refers to the adjustment of the mind to an osseointegrated prosthesis. The implication is that bone-integrated prosthetic fixtures "communicate" with the mind, via numerous neural pathways, to promote near-normal function of the prosthetic limb and improved psychological acceptance. Beethoven, who held a pencil between his teeth and touched the pencil to the piano keys to help him "hear" the music, illustrates a primitive form of this concept. Similarly, patients can perceive their environment through their osseointegrated prosthetic device. A self-reported incident even describes a patient sensing, through his artificial leg, what type of subfloor was beneath a carpet.

Practically, osseointegrated titanium fixtures have a good long-term stability, to date. They have been used successfully in patients who are young and very active—a rancher, a farmer, a woman who has gone on to have two children since receiving her prostheses—and are leading normal lives. A potential area for concern may exist, however, for the very long-term biomechanical feasibility of titanium. Putting an extremely hard material, like titanium, into a softer material like bone creates a stress mismatch, a situation biomechanics cannot change. Ultimately, it might be expected that something could loosen in a very mechanically active site.

Maintenance of the fixtures requires that a patient clean the skin at the area of the titanium bolt penetration once or twice a day. There is a risk of infection, although in most cases this has not proved to be a limiting risk. In older patients having diabetes or vascular disease, a significant number of infectious complications have been noted for prostheses. However, titanium has been used very successfully in the mouth, a highly germ-filled environment.

KEY POINTS

- Osseointegrated titanium fixtures for limb prostheses have been used successfully in Sweden and are now the subject of a European Union clinical trial.
- Careful, precise surgical techniques are required to ensure the osseointegration of a titanium implant.
- The phenomenon of osseoperception enables amputees to achieve greater psychological acceptance of their prostheses.

REFERENCE INFORMATION

1. Brånemark R, Brånemark P-I, Rydevik B, Myers RR. Review. Osseointegration in skeletal reconstruction and rehabilitation. J Rehabil Res Dev 2001;38:175–81.
2. Myers RR, Shubayev VI, Campana WM. Anatomy and pathology of the peripheral nervous system: Neuropathology of painful neuropathies. In: Sommer C, editor. Pain due to peripheral nerve diseases. Basel: Karger; 2001. p. 8–30.
3. Ysander M, Brånemark R, Olmarker K, Myers RR. Intramedullary osseointegration. Development of a rodent model and study of histology and neuropeptide changes around titanium implants. J Rehabil Res Dev 2001;38:183–90.
4. Myers RR. The role of cytokines in nerve injury and pain. In: E Williams, B Rydevik, R Johns, P-I Brånemark, editors. Osseoperception and musculo-skeletal function. Göteborg: Elixir Reklambyrå AB; 1999. p. 49–57.