

# Benefits of osseointegration over socket implants for amputees

*Dr Taylor Reif, of the Hospital for Special Surgery, New York, USA, has conducted a retrospective review of patients who have undergone amputation reconstruction. His work highlights that osseointegration – the process of inserting a metal implant into the bone – brings significant benefits to patients compared to traditional socket implants. Not only does osseointegration improve quality of life for individuals, it allows for more advanced prosthetic designs that offer improved function.*

Prosthetic limbs have given millions of amputees across the world the chance to regain their movement, independence, and quality of life. It's estimated that there are nearly two million people living with limb loss in the US alone.

There are different methods of attaching prosthetic limbs. In the past, the US Food and Drug Administration (FDA) limited the use of certain implants, meaning socket implants attached via a strap or suction mechanism were the most popular form of attaching a prosthesis. But over the past two decades, a technique known as bone-anchored osseointegration has become a popular and emerging treatment due to the advantages it offers over traditional socket implants.

Dr Taylor J Reif and his team at the Hospital for Special Surgery, New York, USA, have carried out a series of studies to investigate the positive impact that bone-anchored osseointegration can bring to patients, and discussed whether the benefits that it can bring outweigh the potential risks that accompany surgery, such as infection or other complications.

## TRADITIONAL SOCKET IMPLANTS

The traditional method for amputees to attach a prosthetic has been via a socket implant, which essentially involves attaching the prosthetic to the residual limb via a bulky socket. This can be achieved via straps, suction, or

a compression mechanism. However, these types of prosthesis are less than ideal for patients. While offering the use of an artificial limb, they unfortunately also come with a litany of potential problems.

Putting the socket on can be aggravating and time consuming. If the fit is poor (and even sometimes if it fits correctly), patients can face issues such as skin irritation, pinching, excessive sweating, ulceration, and range-of-motion limitation. An additional limitation with the traditional socket prosthesis method is poor energy transfer from the bone itself to the prosthesis as they are not truly attached to one another.

This is where a new technique, bone-anchored osseointegration, comes into the picture.

## HOW DOES BONE-ANCHORED OSSEOINTEGRATION WORK?

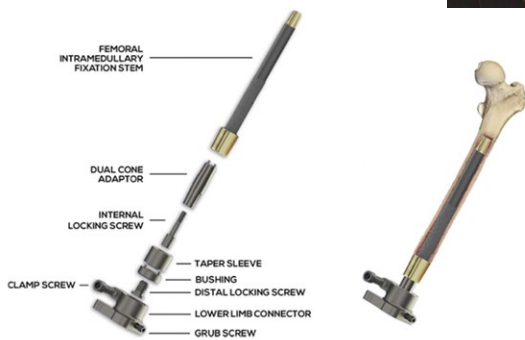
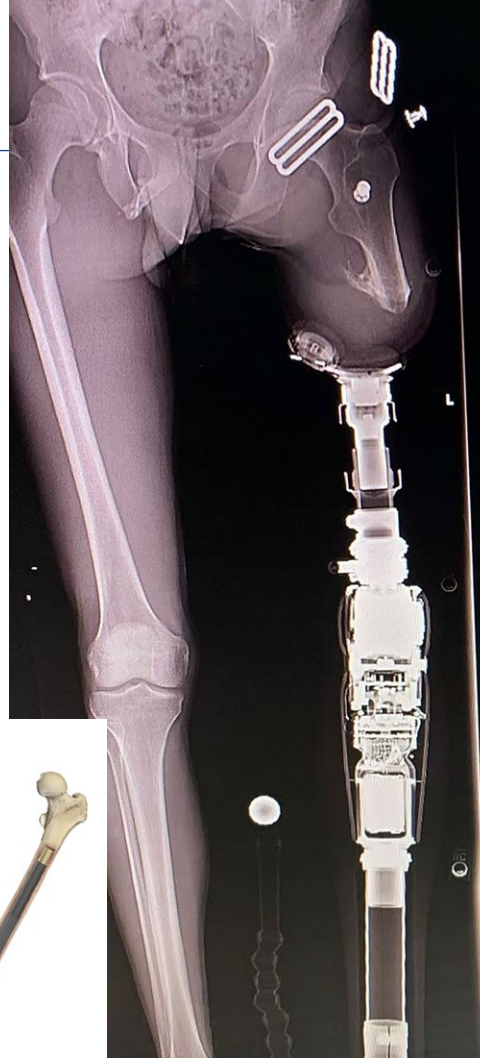
Bone-anchored osseointegration implants are becoming increasingly popular across the world. It removes the need to have a socket fitted at all, as the prosthetic is attached directly to the bone itself. The procedure was first carried out successfully in 1965 by Dr Per-Ingvar Branemark, who attached teeth onto a man's jawbone. In the 1990s his son, Richard Branemark, successfully adapted the technology for use in limbs. It's been widely used in Europe over the past 25 years and this area of surgery continues to develop.



The prosthetic is attached directly to the bone.



Osseointegration allows for more sensory feedback than a traditional socket implant.



The Osseointegrated Prosthetic Limb System is designed to facilitate bone ingrowth.

Bone-anchored osseointegration offers better quality of life in terms of limb control and comfort.

During the amputation reconstruction, a metal implant is inserted directly into the residual bone of the amputee's remaining limb. After a few weeks, the bone grows onto the implant's surface and forms an incredibly strong bond. The strength of this bond means there's a direct connection between the external prosthetic and the bone of the amputee's limb. This gives the patient the ability to move the prosthetic with a direct skeletal connection, giving far greater control than a socket implant. Essentially, osseointegration gives people a more natural connection to their artificial limb.

### OSSEOPERCEPTION

Another benefit of osseointegration is that it allows for a process called 'osseoperception'. This is where external forces and stimuli can be felt through the implant, giving the patient much more sensory feedback from their prosthetic than they would get with a socket implant. For example, they would be able to tell

through touch which type of material they are walking on, and sense vibrations through the ground.

This improved movement and control, combined with the benefits of osseoperception, mean that patients can walk further and wear their prosthetics for longer. They don't have the litany of side effects associated with socket implants, nor do they need to constantly

***There is little doubt that bone-anchored osseointegration offers patients a better quality of life in terms of range of motion, limb control, and comfort.***

attach and re-attach their prosthetic. Overall, osseointegration offers patients an increase in function, mobility, and improved quality of life as an amputee.

This isn't to say that bone-anchored osseointegration is a perfect solution. There has been scepticism from some, specifically around the risks

of infection and implant failure. In particular, concerns have been raised about the potential for an infection with transcutaneous (beneath the skin) metal implants. Through their research, Dr Reif and his team sought to weigh up these risks against patient benefits.

### WHAT DOES THE LITERATURE SHOW?

Dr Reif and colleagues carried out a literature review and assessment of their own patients to better understand patient experiences and outcomes following

bone-anchored osseointegration. The success of the operation was assessed through functional tests and patients' experiences and opinions, based on pre-operative and post-operative questionnaires. Known as QTFA (Questionnaire for persons with TransFemoral Amputations), these were designed to help measure the success





There is little doubt that osseointegration offers better quality of life.

of the osseointegration procedure against socket prosthetics.

Their 2021 paper retrospectively reviewed the results of 31 patients who had undergone the implantation of a press-fit osseointegration of the femur (thigh bone) or tibia (shin bone). All patients had had their operation performed at least six months previously. Dr Reif found that osseointegration implants indeed improved the overall experience of patients when compared to that of people with socket prosthetics.

The functional tests demonstrated that patients with osseointegration implants showed significantly better outcomes and were able to walk greater distances when compared with traditional socket prosthetics. The researchers noted that general pain improved on average, and pain interference was significantly improved.

The study highlighted a few early problems, but in 93% of those cases the issues were resolved without having to remove the prosthesis. Complications were manageable enough to encourage the ongoing use of the technology. The most common problems were

soft-tissue infections and simple mechanical failures.

Another study in 50 Swedish patients found QTFA scores improved significantly across all categories after osseointegration. Even the four patients who did experience problems requested the reimplantation of their prosthetic after the issue was resolved. Similar results were found in groups of patients from Australia, Germany, and the Netherlands.

A separate 2021 study showed a further benefit of osseointegration – the fact that it allows for better designs of prosthetics. It details the experiences of two patients who underwent osseointegration after arm amputations. They were fitted with myoelectric prosthetics, which are able to sense electrical signals from the muscles in the arm. The patients were trained to use this technology with pattern-recognition software that allowed them to control the hand and wrist of the myoelectric prosthetic.

the short and long term, and the risk of infection remains manageable. Dr Reif explains, 'these studies emphasise the overall satisfaction, deemed revolutionary by many, subjectively reported by patients while using a bone-anchored prosthesis instead of a socket.'

#### **FUTURE IMPLICATIONS FOR AMPUTEE PROSTHETICS**

Dr Reif's research shows that there is little doubt that bone-anchored osseointegration offers patients a better quality of life in terms of range of motion, limb control, and comfort, versus socket implants. He notes that the risk of infection will never be removed entirely; patients who do need their prosthetic removed to deal with an infection usually opt to have it reattached via osseointegration.

The researchers did note some limitations of the studies they reviewed, such as the relatively small number of patients and lack of long-term follow-up.

## ***Osseointegration offered higher patient satisfaction in both the short and long term, and the main risk of infection was a relatively manageable one.***

After two years the myoelectric prosthetics had shown no signs of loosening, and patients had gradual improvements in their standards of daily living. This exciting new technology would not have been possible using socket prosthetics instead of osseointegration.

#### **LONG-TERM RESULTS OF OSSEOINTEGRATION**

It can be more challenging to give a long-term answer to whether osseointegration is effective; Dr Reif notes that most centres would like to carry out long-term follow-up appointments with their patients, but are unable to do so as many people don't return for these appointments. This is especially true if the patients are doing well post-surgery. However, a few studies examined outcomes after five, ten, and 15 years post-osseointegration. Overall, the literature showed that osseointegration offered higher patient satisfaction in both

They suggest that studies to explore differences between different implant techniques and implants at different parts of the body would be beneficial, as well as investigating the potential financial benefits of osseointegration. Amputees using socket implants need to have routine socket changes every few years, or sometimes even more regularly if they've been experiencing difficulties. Factors worth comparing would include productivity, mental health, and time to return to work.

Osseointegration bestows a direct structural and functional connection between the bone and implant. Dr Reif's studies highlight the overwhelming benefits of osseointegration over traditional socket implants, and supports its continued adoption and development. Osseointegration offers an exciting opportunity to greatly improve the daily living standards of the millions of people living with limb loss.

# Behind the Research



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## Research Objectives

Dr Taylor Reif conducted a review of patients who have received an osseointegration implant for prostheses, analysing the outcomes for amputees.

## Detail

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### Bio

Taylor J Reif attended Northwestern

University, graduating with a BS in biomedical engineering. He continued at Northwestern's Feinberg School of Medicine, graduating with AOA Honors. He completed his orthopaedic surgery residency at Loyola Medical Center and pursued subspecialty surgical training

in musculoskeletal oncology at Shands Cancer Center and limb lengthening and deformity correction at Hospital for Special Surgery.

### Collaborators

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## Personal Response

### Where would you like to see the world of prosthetics in ten years' time?

// As osseointegration grows and prosthetists are able to spend less time fashioning sockets and instead rely on a stable bone anchorage, I think they will get more creative with the components they use, including heavier robotic components for the hands and feet that have greater functionality for patients. An even greater advancement will occur when the signals from residual nerve endings in the limb can be routed through the osseointegration components to allow improved motor control and sensory feedback of the robotic components. //



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