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The development of a component to improve the loading safety of bone-anchored prostheses.
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The development of a component to improve the loading safety of bone-anchored prostheses

PhD Outline

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Abstract

Use of socket prostheses

Currently, for individuals with limb loss, the conventional method of attaching a prosthetic limb relies on a socket that fits over the residual limb.[1] However, there are a number of issues concerning the use of a socket (e.g., blisters, irritation, and discomfort) that result in dissatisfaction with socket prostheses, and ultimately a significant decrease in quality of life.[2-9]

Bone-anchored prosthesis

Alternatively, the concept of attaching artificial limbs directly to the skeletal system has been developed (bone anchored prostheses), as it alleviates many of the issues surrounding the conventional socket interface.[10, 11] Bone anchored prostheses rely on two critical components: the implant, and the percutaneous abutment or adapter, which forms the connection for the external prosthetic system (Figure 1).

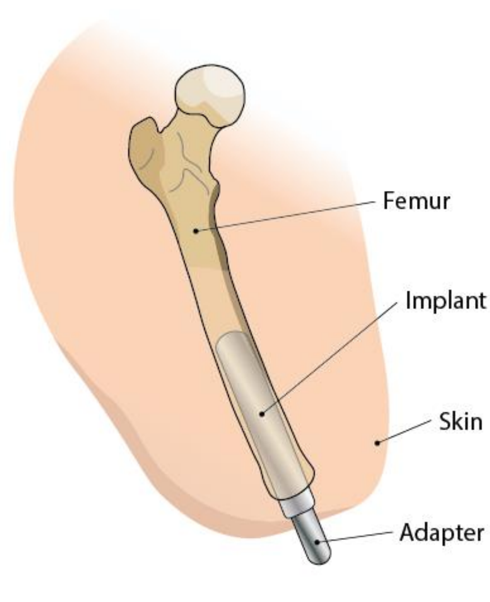

Figure 1. Diagram of a bone anchored prosthetic system.

To date, an implant that screws into the long bone of the residual limb has been the most common intervention.[12, 13] However, more recently, press-fit implants have been introduced and their use is increasing.[14-16] Several other devices are currently at various stages of development, particularly in Europe and the United States. [10, 17-32]

Benefits of bone-anchored prostheses

Several key studies have demonstrated that bone-anchored prostheses have major clinical benefits when compared to socket prostheses (e.g., quality of life [13], prosthetic use [6, 33], body image [34], hip range of motion [35], sitting comfort [36], ease of donning and doffing [6], osseoperception (proprioception) [37, 38], walking ability [33, 39]) and acceptable safety, in terms of implant stability [40] and infection [13, 41]. Additionally, this method of attachment allows amputees to participate in a wide range of daily activities for a substantially longer duration.[42-45] Overall, the system has demonstrated a significant enhancement to quality of life.[6, 13, 16, 33, 46]

Challenges of direct skeletal attachment

However, due to the direct skeletal attachment, serious injury and damage can occur through excessive loading events such as during a fall (e.g., component damage, peri-prosthetic fracture, hip dislocation, and femoral head fracture). [39, 42-45, 47-52] These incidents are costly (e.g., replacement of components) and could require further surgical interventions. Currently, these risks are limiting the acceptance of bone-anchored technology and the substantial improvement to quality of life that this treatment offers.

An in-depth investigation into these risks highlighted a clear need to re-design and improve the componentry in the system (Figure 2), to increase the overall safety during excessive loading events.

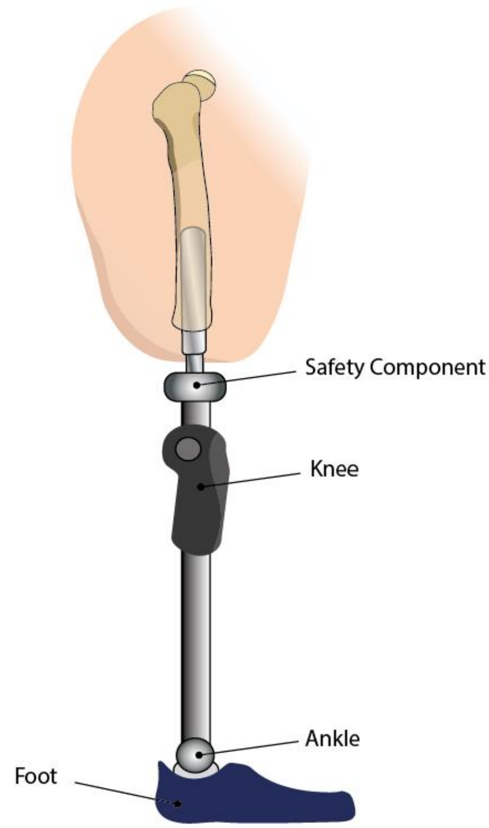

Figure 2. A complete bone-anchored prosthetic system, displaying the external components.

Aim and purposes

The ultimate aim of this doctoral research is to **improve the loading safety of bone-anchored prostheses, to reduce the incidence of injury and damage through the design of load restricting components,** enabling individuals fitted with the system to partake in everyday activities, with increased security and self-assurance. The safety component will be designed to release or 'fail' external to the limb, in a way that protects the internal bone-implant interface, thus removing the need for restorative surgery and potential damage to the bone.

This requires detailed knowledge of the

loads typically experienced by the limb and an understanding of potential overload situations that might occur. Hence, a comprehensive review of the loading literature surrounding bone anchored prostheses will be conducted as part of this project, with the potential for additional experimental studies to address the gaps in the literature.

This information will be pivotal in determining the specifications for the properties of the safety component, and the bone-implant system.[39, 42-45, 47-64]
The project will follow the Stanford Biodesign process for the development of the safety component.[65]

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