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SUBSPECIALTY PROCEDURES

Single-Stage Press-Fit Osseointegration of the Radius and Ulna for Rehabilitation After Trans-Forearm Amputation

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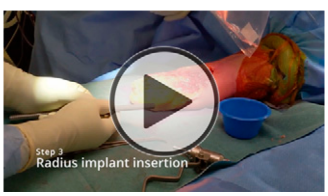
Published outcomes of this procedure can be found at: *Acta Orthop*. 2008 Feb;79(1):78-85, and *Prosthet Orthot Int*. 2011 Jun;35(2):190-200.

Investigation performed at the Limb Reconstruction Centre, Macquarie University Hospital, Macquarie University, Sydney, New South Wales, Australia



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Abstract

Background: Upper limb (UL) amputation is disabling. ULs are necessary for many domains of life[1], and few effective motor and sensory replacements are accessible[2]. Approximately 41,000 people in the United States have UL amputation proximal to the fingers[3], two-thirds of (all) traumatic amputations are UL[4], and 80% of UL amputations are performed for trauma-related etiologies[5]. Socket prosthesis (SP) abandonment remains high because of the lack of sensation, limited prosthesis control, perceived weight, and difficulty comfortably wearing the SP[6]. Transcutaneous osseointegration[7,8] surgically inserts a bone-anchored implant, passed through a transcutaneous portal to attach a terminal device, improving amputee rehabilitation by reducing perceived weight, conferring osseoperception[9], and increasing wear time[10]. Without the socket, all residual skin and musculature remain available for transcutaneous myoelectrodes. The present article describes single-stage radius and ulna press-fit osseointegration (PFOI) after trans-forearm amputation.

Description: This technique resembles a lower-extremity PFOI[11,12]. Importantly, at-risk nerves and vessels are different, and implant impaction must be gentler as a result. The surgery is indicated for patients who are dissatisfied with SP rehabilitation or declining alternative rehabilitative options, and who are motivated and enabled to procure, train with, and utilize a forearm prosthesis. An engaged prosthetist is critical. Surgical steps are exposure, bone-end and canal preparation, first implant insertion (in the operative video shown, in the radius), purse-string muscle closure, confirmation that radius-ulna motion remains, performing the prior steps for the other bone (in the video, the ulna), and closure (including potential nerve reconstruction, soft-tissue contouring, and portal creation). Although the patient in the operative video did not require nerve procedures to address pain

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or to create targets for transcutaneous myoelectrodes, targeted muscle reinnervation or a regenerative peripheral nerve interface procedure could be performed following exposure.

Alternatives: Alternatives include socket modification, bone lengthening and/or soft-tissue contouring[13], Krukenberg-type reconstructions[14], or accepting the situation. An alternative implant is a screw-type osseointegration implant. Our preference for press-fit implants is based on considerations such as our practice's 12-year history of >1,000 PFOI surgeries; that the screw-type implant requires sufficient cortical thickness for the threads[15], which is compromised in some patients; the lower cost per implant; that the procedure is performed in 1 instead of 2 surgical episodes[15,16]; and the documented suitability of press-fit implants for patients with challenging anatomy or comorbidities[17-19].

Rationale: PFOI can be provided for amputees having difficulty with socket wear. PFOI usually provides superior prosthesis stability, which can confer better prosthesis control versus nonoperative and other operative options in patients expressing dissatisfaction for reasons such as those mentioned above, or for poor fit, compromised energy transfer, skin pinching, compression, and abrasions. For patients who want myoelectric control of their prosthesis but who are unable because the optimal myoelectric location is obstructed by the socket, osseointegration may provide access for the electrodes by eliminating the socket.

Expected Outcomes: Only 3 trans-forearm osseointegration[20-22] publications totaling 10 limbs could be identified, limiting the ability to determine generalizable outcomes. Osseointegrated prostheses, being skeletally anchored, feel lighter to patients than SPs, which should confer better outcomes. In 1 patient, multiple implant fractures and infection prompted additional surgeries. Periprosthetic bone fractures and non-infectious loosening have not been documented for UL osseointegration.

Important Tips:

- Osseointegration eliminates the socket, relieving socket-based pain. However, neurogenic pain relief requires specific nerve procedures.
- Osseointegration provides a prosthesis connection. Nerve- or muscle-based prosthesis control requires separate, potentially integrated planning.
- Osseointegrated prostheses confer osseoperception (i.e., mechanical force transmission), not "normal" skin-mediated afferent sensation (i.e., light touch, temperature, pain) or native proprioception.
- Prostheses must be individualized to the patient's elbow flexion and radioulnar rotation. An attentive prosthetist must be ensured preoperatively.
- Achieving the demonstrated outcomes requires more therapy and retraining than walking with an osseointegrated lower-extremity prosthesis. Patients must expect at least several months of spending multiple hours daily engaging in self-directed rehabilitation.
- Prosthesis utilization decision aids[23] may minimize non-beneficial surgeries.

Acronyms and Abbreviations:

- UL = upper limb
- SP = socket prosthesis
- PFOI = press-fit osseointegration
- peri-pros fx = periprosthetic fracture
- MRI = magnetic resonance imaging
- CT = computed tomography

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