Problem: Bilateral upper extremity amputation is an extremely rare situation that requires collaboration among the individual and rehabilitation team to restore independence and function through creative solutions (1, 2). Eating is particularly challenging for individuals with bilateral upper-limb-loss (1, 2). A wide variety of adaptive eating utensils, prosthetic attachments, and custom solutions exist to increase independence with feeding (1, 2). Some of these solutions are cost prohibitive while others are utilized temporarily until a more permanent solution for eating is acquired. As either a permanent or temporary solution, the universal cuff is one common tool that fits around an individual's residual limb to hold a fork or spoon (1, 2). However, the universal cuff is susceptible to rotating, twisting, and slipping on the user's limb and does not stabilize the eating utensil when pressing into tough, firm foods such as meat.

Approach: The “U-Cuff Stabilizer” was developed in collaboration with a consumer of assistive technology during a larger project to investigate the feasibility of offering 3D printing services at the university's assistive technology center. The collaborating individual experienced bilateral below knee and below elbow amputations approximately two years prior. He currently uses a power wheelchair for mobility and is waiting for delivery of lower extremity prosthetic limbs. The individual was identified by clinicians as someone who may benefit from unique 3D printed solutions to help address challenges with mobility or activities of daily living. At the initial encounter, the individual demonstrated excellent strength and independence during functional mobility, but reported frequent difficulty with certain aspects of feeding, grooming, and other daily activities. The individual described his particular frustration with using a universal cuff for eating because it failed to stabilize his fork when pushing into tougher foods such as meat. His existing universal cuff and fork are shown below in Figure 1. He complained that the universal cuff would twist on his forearm instead of penetrating the food and it required support from his opposite extremity to minimize the cuff’s rotation. Positioning his body to achieve the preferred utensil angle to his food while simultaneously supporting the universal cuff with his opposite limb created a source of discomfort and embarrassment especially when eating in public.
Final Approach and Design: At a second encounter, the individual was presented with a variety of utensil holder designs available commercially or shared through open source websites. Possible options were ruled out based on size, aesthetics, number and complexity of components, and potential to create similar issues with rotational instability. Collaboration at this meeting resulted in a concept sketch for a utensil holder that would integrate with the individual’s existing universal cuff. Dimensions were taken of the individual’s dominant forearm to customize the fit of the proposed utensil holder. Trial and error of various fork positions during simulated eating helped establish a utensil angle of 45 degrees from the dorsal aspect of the forearm. The individual supplied a fork from home to assure the new holder would be compatible with his personal utensils. The agreed upon concept was then 3D modelled and printed in ABS plastic for the individual to trial at his next appointment one week later. The initial “U-Cuff Stabilizer” is shown below in Figure 2 which also shows the device as worn by the individual.
Outcomes: Approximately two weeks after the first encounter, the initial “U-Cuff Stabilizer” was delivered to the individual who then trialed the new component for the following week. After one week of use, the individual reported excellent results when using the “U-Cuff Stabilizer” during meals. He specifically reported using the device to eat chicken and pasta with one upper extremity and no rotation or slippage of the universal cuff on his forearm. He also successfully used the “U-Cuff Stabilizer” with a spoon to eat cereal. He indicated significant improvement in comfort while eating due to increased utensil security and a more preferred utensil angle relative to his food. He additionally stated that the “U-Cuff Stabilizer” created a natural eating style because it did not require awkward body positions to support his fork with both upper extremities as previously required when piercing certain foods. Thus, the individual is looking forward to using the new device at restaurants and eating with greater confidence in public. One request was that a thin rubber padding be added to the internal surface of the device for added comfort. A demonstration of the “U-Cuff Stabilizer” can be viewed at the following link: https://youtu.be/d_7wacT26Lw
Cost: The material cost for one 3D printed “U-Cuff Stabilizer” is estimated in the $5-$10 range which does not capture the costs associated with engineering and clinician involvement. It would be expected that a less customized version of the component could be produced for significantly less using manufacturing processes other than 3D printing and then priced accordingly. The expense to consumers and business feasibility of offering 3D printing services at the university’s assistive technology center to create custom solutions such as the “U-Cuff Stabilizer” is still being investigated.

Significance: The “U-Cuff Stabilizer” project highlights the value of collaboration with assistive technology consumers and the potential for 3D printing to generate rapid solutions to common or individualized problems. Upon first encounter, the individual with bilateral below elbow amputations quickly identified the need for an improved method of securing his fork while eating dense foods such as meat. Existing devices were identified and ruled out before investigating the possibility of 3D printing a new solution. Access to a 3D printer allowed elements of the engineering design process to be completed in only a few weeks. The resulting “U-Cuff Stabilizer” component offers a quick, simple, inexpensive, and effective solution for improving the utensil holder functionality and security of an off-the-shelf universal cuff. During meals, the “U-Cuff Stabilizer” adapts to an existing universal cuff to eliminate unwanted rotation on the user’s forearm and promotes a more natural eating style. The inside dimensions of the “U-Cuff Stabilizer” were dimensioned and contoured to provide a custom fit for the collaborating individual; however, a generic contour could easily produce an acceptable fit for a wide variety of forearm shapes. Depending on user preference, the “U-Cuff Stabilizer” could offer a permanent solution as an eating utensil holder or a temporary fix until more advanced prosthetic eating attachments are received.
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