MECHANICAL CHANGES AND NEW CONTROL OPTIONS
IMPROVE THE FUNCTION OF THE LTI-COLLIERSHOLD JOINT

T. Walley Williams, III
Liberating Technologies, Inc.
325 Hopping Brook Road – Suite A
Holliston, MA  01746-1456

INTRODUCTION

When a new prosthetic component is introduced to the market, it often needs further improvements or accessory devices that only become apparent when clients and clinicians have had a chance to put the device to all of its possible uses. Since the LTI-Collier Locking Shoulder Joint was introduced, a number of improvements have been made both in the product and its accessories in response to user feedback. In the original concept, the user was assumed to need to unlock only momentarily between activities. For most users this assumption is wrong. The most popular feature of the joint turns out to be its ability to remain in free swing. Improvements in the joint itself have either added strength where required or have increased the number of users who can readily put the joint into free swing. To make free swing accessible to more amputees, an electric elbow lock was developed. There are now many ways to activate this lock.

REDUCING FRICTION DURING UNLOCKING

The unlocking lever should move easily when pulled, and then it should snap back into the locked position quickly. A bearing, consisting of six balls placed under the ring, reduced friction by half. It is now easier for the user to activate; but more important, the lock fully engages more reliably, which increases the life of the mechanism.

MAKING THE UNLOCK CABLE EASY TO INSTALL

The lever that unlocks the joint requires a tangential force in the plane of rotation for activation. Prostheses returned for repair showed that people were neither attaching the activation cables to the lever tangentially nor at the right height. Furthermore the cables could not be tensioned properly causing wear inside the joint. A new anchor plate was designed to correct these problems. It mounts under the joint and will clamp any Bowden cable so that it points directly at the operating point on the lever. Tension is adjusted by moving the cable sheath under the clamp. There are three choices for cable operation of the unlocking mechanism. They are built out of Blatchford knee lock mechanisms or the Hosmer Sierra Nudge Control. With all units the standard cable is replaced by a heavy-duty sheath and a Teflon™ liner. The Blatchford units are also supplies with an added mounting plate. Figures 1 and 2 show the unit before and after the change while Figure 3 shows the optional mounting plate supplied with the Blatchford units. This plate makes it easier to mount the mechanism on the outside of a prosthesis.
Figure 1. This mounting bends the cable as it attaches to the lever, and the clamp is far below the plane of the lever.

Figure 2. This new plate lines up the cable sheath perfectly. To adjust tension loosen the clamp and move the sheath.

Figure 3. This optional mounting plate makes the Blatchford unit accessible from the top.

THE UPPER-ARM ATTACHMENT PLATE

The original joints were supplied with an upper-arm attachment plate that could be bent when an offset was required. Because the alloy had a low yield, it also bent under normal usage, and failed on heavy users. However, the ability to provide an offset was a popular feature. Redesign of the plate was the answer. The new high-strength plate has a bend on one end and is 50% thicker than before. Strength has been doubled. The bend is permanent because the new alloy cannot be bent by ordinary means. Since not everyone wants an offset, there are attachment holes on both ends. To choose between an offset and a straight plate technicians simply cut off the end they do not need. The piece that holds the plate to the joint has also been made thicker, and the friction screw is easier to turn. These changes add a little weight but greatly improve reliability. There have been no failures since they were made.

Figure 4. The heavy-duty bent plate is used here to attach a temporary upper arm fitting to a Boston Elbow.
PROVIDING HANDS-FREE UNLOCKING

The people who need a locking shoulder most are those with bilateral involvement. They cannot simply reach over and push a lever. At first the only choice was to use the Hosmer Sierra Nudge Control. However, many users already had too many controls around their chins, so an electric unlock mechanism seemed in order. Several units were jury rigged out of available cable activation units, and proved that a custom design was needed. [1] Figure 5 shows the present Electric Lock/Unlock for an LTI joint. The mounting bracket is a thin plate that goes under the joint. It holds a motor, reduction gear, and screw-activated sliding block. The block engages the unlock lever. A 6V battery will drive the block back and forth to lock and unlock the joint. Note that an offset upper-arm plate may be used to keep the motor and upper arm from interfering.

Activating The Electric Lock

Motor activation is simple in principle, but the details can cause difficulty. The motor was selected to operate from 6 to 9V, but at the high end of this range it can be damaged if run continuously. When the lock is to be switch operated, it is supplied with a series Polyfuse™. With a control circuit, motor stall current can be sampled to stop the motor, so a fuse is not required. The clinical challenge with the lock is minimizing battery weight. Whenever another battery-operated device is present, the two units should share a common battery if possible. As for controllers, a spare hand-control circuit will work well if it incorporates the battery saving feature. Otherwise, one of LTI’s many VariGrip II controllers will do. The lock works best when it is teamed up with the LTI Boston Digital Arm. The arm program offers the clinician more control choices than any other system, but there are almost as many choices with the VariGrip II.
Control Choices

While the lock functions well when operated by a current-carrying switch, this setup forces the user to remain in contact with the switch until the lock or unlock operation is complete. Users much prefer to simply touch a switch with the circuit taking over completion of the task. With the Boston Arm or VariGrip II controllers there are many ways to activate the Lock. They all can be set up so the user triggers the operation, which is then completed automatically. A single switch closure, push on a Touch Pad™, or cocontraction can trigger the circuit to alternately lock and unlock the joint. Since the user can hear the motor activate, no user feedback is required. Users can even be trained to use more than one cocontraction strategy, so that one type shifts myoelectric control between devices, while a second triggers the alternate lock-unlock action.

User Convenience

It is worth mentioning some of the choices that users have requested. A simple chin-activated switch is popular, but other locations often work better. One unilateral user needed to place his arm out front for work tasks. For him a switch was placed on the forearm, where it could be activated by the same hand motion being used to reposition the arm. For other users an extra Touch Pad has been used as a trigger. Simple body motions are best. Another motion is that of a short humeral neck. It can push out against a Touch Pad or switch.

The Triggering Spike

Sometimes a user will have a weak muscle that cannot be used for proportional control. If the muscle can generate a momentary spike of activity, however, it may be ideal for operating the lock. In fact any momentary signal can be used. Recently LTI has reexamined the problem of triggering the selection of multiple devices. While the rapid cocontraction is the least likely trigger to be inadvertently activated, there are other unique patterns. For instance a momentary strong spike of a single muscle can be characterized such that it becomes another trigger choice. Use of existing myoelectric sites avoids adding switches and other extra hardware.

REFERENCES