3.
Alternatives to the Boston Elbow

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PROSTHETIC ALTERNATIVES

There are three major prosthetic alternatives to the Boston Elbow. In order of technical sophistication they are: the conventional, body-powered elbow prosthesis; a switch-controlled electric elbow; and another myoelectrically controlled arm, Each can be found in a small prosthetics market, where five firms account for 95 percent of the sales, and sales to prosthetists were an estimated $31 million in 1981. About 55 percent or $17 million was spent on upper extremity prostheses, although (less costly) lower extremity devices were bought in larger numbers. An estimated $5 million was spent on *above elbow* prostheses in 1981 (37).

The largest prosthetics firm by market share is Otto Bock, U. S. A., a division of a West German company. Bock, U.S.A. reported earnings of $11 million in 1981, and this represented about one-third of all U.S. prosthetics industry earnings. The firm does not make elbows, although it does furnish prosthetists with switches to be used in assembling elbows made by other companies. A myoelectric hand prosthesis is one of Bock's most widely used products (37).

The body-powered elbow is the oldest and most frequently worn of the above-elbow prostheses. It is designed so that a steel cable running the length of the arm is under the control of the amputee, who rolls his or her shoulder to flex the elbow and relaxes to allow gravity to extend the prosthesis.

A body-powered prosthesis is not an innate device. It requires unnatural shoulder movements on the part of the user and does not permit the elbow and terminal device to operate at the same time. Because the prosthesis is powered by the amputee, it *is less* powerful than prostheses with batteries and less likely to be good for lifting and holding. On the other hand, the cable-operated arm is lighter than most externally powered devices (see table 3 in ch. 2), and weight is an important consideration for most amputees. A conventional elbow is also virtually noiseless and has a relatively long life of more than 10 years. Its cost is about $400 for the elbow alone and $1,500 fitted to the amputee.

The Hosmer Dorrance Corp. sells the largest number of body-powered elbows. Hosmer is the second largest firm in the prosthetics market, with earnings of $7 million in 1981 (37). In 1983 Hosmer began to market a switch-controlled electric elbow as well.

All commercially available externally powered elbows are electric, that is, they run on batteries. Means of controlling the prostheses differ, however. A control mechanism less sophisticated than the Elbow's is the pull-switch found on the Veterans Administration (VA) Elbow (sometimes called the VA Prosthetics Center or VAPC Elbow). Amputees are able to turn pull-switch prostheses on and off with very slight shoulder movements and, of course, need not power the device themselves. The VA Elbow weighs less than the Boston Elbow (table 3) and has a slimmer forearm. But the VA Elbow is not proportional, so it moves at only one (relatively slow) speed. Nor is it strong enough to lift more than 3 pounds or hold more than 12 pounds. The cost of the VA Elbow is $900 alone and about $2, 000 fitted to the amputee.[2] It was designed at the VA but is manufactured currently by Fidelity Electronics, the third largest manufacturer of upper extremity devices. Fidelity offers an externally powered hand as well as the VA Elbow and earned an estimated $1 million from the manufacture of limbs in 1981 (37).

The Utah Arm is the only commercially available myoelectric alternative to the Boston Elbow.

'Unless otherwise noted, data for *Prosthetic Alternatives* are from interviews with prosthetists and manufacturers, and promotional materials from the latter.

"'Fitted to the amputee" includes such items as socket and training.

It is, in fact, progeny of the latter, having been designed by Stephen Jacobsen, who studied with Mann at MIT. Jacobsen's original idea was to extend the logic of the Boston Elbow to multiple arm functions. He found that myoelectric control was possible not only with biceps and triceps muscles but with muscles around the shoulder as well. These "anticipate" what joints such as the elbow are about to do. The Utah Arm is designed to use this information for as full a set of arm functions as possible. At present, the elbow is still the Arm's only powered joint (excluding a powered terminal device, which may be worn with a Boston Elbow as well). The Utah Arm elbow costs $10,000 alone and an average of $20,000 fitted to the amputee. It is manufactured by a firm called Motion Control, which was founded by Jacobsen in 1974 for the purpose of marketing the Utah Arm.

The Boston Elbow and the Utah Arm are derived from the same idea; as a result, both are myoelectric and proportional. They do, however, diverge at several points, and these differences seem to indicate a divergence of objectives as well. First, the Utah Arm is a more attractive prosthesis than the Boston Elbow. The former has a slimmer forearm and is less noisy, and because it has completely free swing, the Utah Arm is also more natural looking. The Boston Elbow, in contrast, has a boxy forearm and only 30 degrees of free swing. It weighs more than the Utah Arm but will lift more weight. The makers of the Boston Elbow favor a capacity for simultaneous movement of the elbow and terminal device—this having been Glimcher's concern in initiating the Boston Elbow project. When the Utah Arm is worn with a powered terminal device, the 2 degrees of freedom have a single control site and therefore can be operated only sequentially. The Arm thereby loses what, at least according to Glimcher, is an important aspect of functioning. Technically, the Utah Arm and the Boston Elbow both can be wired for simultaneous movement of the elbow and the terminal device or for single-site control. Liberty Mutual has chosen to implement the first and Motion Control, maker of the Utah Arm, the second option.

An additional point of contrast is that the Boston Elbow will run for about 8 hours and then requires 2 hours of recharging, during which time the amputee must do without it. The Utah Arm runs for about the same amount of time (half as long if a powered terminal device is being worn), but the battery pack can be removed for recharging and replaced on the spot with batteries that are fully charged. This means that although recharging the Utah Arm takes 16 hours as opposed to 2 hours for the Boston Elbow, users of the Utah Arm can acquire a sufficient number of batteries and chargers to have a functional prosthesis whenever they wish.

The Boston Elbow emerges from this discussion as a "worker's" arm. If it is to be worn primarily at work, cosmetic strengths may be less important than functional ones, and 8 hours of power are likely to be enough. Liberty Mutual also markets the Boston Elbow as a worker's arm. Promotional materials feature a photograph of a middle-aged man in a tie repairing a television set. The caption reads: "Soldering requires the precise positioning of both the solder and the iron. " Later in the same advertisement, the Boston Elbow battery is described as powering "a full 8-hour workday." The Utah Arm brochure, in contrast, features a young woman in blue jeans who is shown socializing with other young people. In correspondence for this study, a Liberty Mutual official listed Boston Elbow wearers by name, address, and occupation. One retired amputee whose Elbow needed adjustment said he would not return to Liberty Mutual for the repair because younger people deserved the firm's full attention. In conversation about the same man, a Liberty Mutual official indicated that his own interest in making the repair was diminished because the amputee no longer needed the prosthesis for work.

A work orientation is not implicit in above-elbow prosthetics. In a limited number of interviews, Motion Control officials spoke consistently about reproducing the human arm, about building a device that feels real to the amputee. Work is, however, the lens through which Liberty Mutual views its prosthesis—hardly surprising given the firm's interest in the workers' compensation insurance market and the fact that the Boston Elbow's development and refinement themselves took place among workers' compensation clients. These were individuals who had been injured in the workplace, and whose reemployment was at the heart of the rehabilitation process.

Photo credit: Motion Control, Salt Lake City, UT

Photo credit: Liberty Mutual Insurance Co., Boston, MA

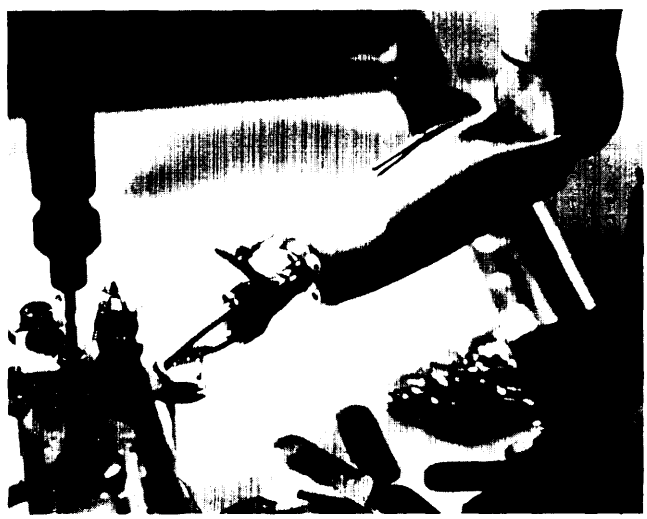

Photo credit" Ltberty Mutual Insurance Co , Boston, MA

Left: This woman is wearing a Utah Arm, which has a slim forearm and a completely free swing. Top right: The Boston Elbow, which this man is using, was originally developed to facilitate reemployment of people who had been injured in the workplace. Botton right: A person using a Boston Elbow, shown here, can simultaneously move the elbow and the terminal device

NONPROSTHETIC ALTERNATIVES

Some alternatives to the Boston Elbow are not limb prostheses at all. Many amputees, for instance, learn to function with one arm. Some learn by trial and error. Others work with occupational and physical therapists. It is estimated that approximately half of the above-elbow amputees decline to wear a prosthesis. Although some rehabilitation professionals consider this defeatist and unacceptable, even prosthetists admit that it is possible, with good training, to do most of what is essential with one arm. Loss of the upper extremity differs from that of the lower on just this point. Legs do things in pairs, while a single arm can function independently. Amputees who have lost both arms of course have a greater need for prosthetic devices.

Not wearing a prosthesis can have a psychological as well as physical aspect. Rehabilitation entails psychic accommodation to a new reality, and coming to terms with functional loss can lessen the need for and desirability of an artificial limb. One blind speaker told a recent workshop that the approach of rehabilitation technology to disability was counterproductive and certain to fail. Technology, he argued, serves only to impede adaptation, which he defined as a set of compensatory behaviors and beliefs (17). Some amputees feel that not wearing a prosthesis is more self-affirming. Max Cleland, for example, a triple amputee and former head of the Veterans Administration, related that he was relieved when his physician ordered him off his artificial legs. Wearing them, according to Cleland, was a matter of "machismo," something he had to get over before he could love himself again (7). Other amputees forego a prosthesis to make a political statement—to make able-bodied people come to terms with the physical impairments of others.

That above-elbow amputees sometimes decide against prosthetic devices is in no way an indication that their loss is trivial. One need only tie an arm behind one's back to discover how great a functional loss upper extremity amputation is. Rather, abstention from prostheses testifies to the adaptability of human beings and to how poor a substitute devices are for the human arm.

Money is a second kind of nonprosthetic compensation for the loss of an arm. Private and public programs provide amputees with monetary benefits designed to mitigate impairment; these replace lost earnings and purchase services for amputees should they require help. Money may come in two forms, indemnity and income maintenance. An indemnity is a previously established sum considered fair compensation for a specific anatomical loss. Thus, every individual with the same amputation receives an indemnity payment of the same amount from any one program. Benefits are set to reflect lost wages in a very general way, but an indemnity is not means-tested. An amputee receives the full sum regardless of his or her employment status or assets. As will be discussed further in chapter 4, veteran disability compensation and most worker's compensation programs provide indemnity benefits.

The second form of monetary compensation is income maintenance. This is a program of cash transfers, usually scaled to need and based on the assumption that impairment has a negative effect on labor force participation. Benefit levels are set to provide for basic needs, but because amputees' earnings may make them ineligible for the program, income maintenance is widely thought to be a disincentive to work. Veterans pensions, Social Security Disability Insurance, and Supplemental Security Income pay income maintenance benefits. They will be discussed more fully in chapter 4.

Yet a third alternative to prosthetic arms is to adapt the environment in which the amputee lives and works. Environmental strategies may seem more appropriate for people in wheelchairs than for upper extremity amputees, but the latter can benefit from automobile adaptation, specialized kitchen and bathroom equipment, and assistive devices such as a button hook or an adapted telephone. Moreover, environmental modifications may be social as well as physical, i.e., they may mitigate functional loss by modifying the human relationships in the amputee's environment. Rehabilitation legislation of the last decade, for example, has outlawed discrimination against people

with disabilities by some employers and service providers. This makes jobs and services more accessible to amputees, which in turn has monetary and social benefits. Specific environmental programs will be discussed in the next chapter.

To summarize, the above-elbow amputee has both prosthetic and nonprosthetic alternatives to the Boston Elbow. Each replaces some of what was lost with the arm. None provides complete restoration.