Hydraulic Crutch as a Source of Internal Power for Orthotics and Prosthetics

by

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INTRODUCTION

Non-powered, or passive, orthotic and prosthetic devices have been used since antiquity. Acceleration, deceleration, or the momentum of more proximal portions of the limb provide their motive force.

In recent years, external power has come into use for driving assistive devices (1,2). Compressed gas and electricity are the power sources most commonly used at this time. Problems of control are probably the severest limitations to the application of external power systems (3).

There has been less exploitation of potential sources of internal power obtained from intact

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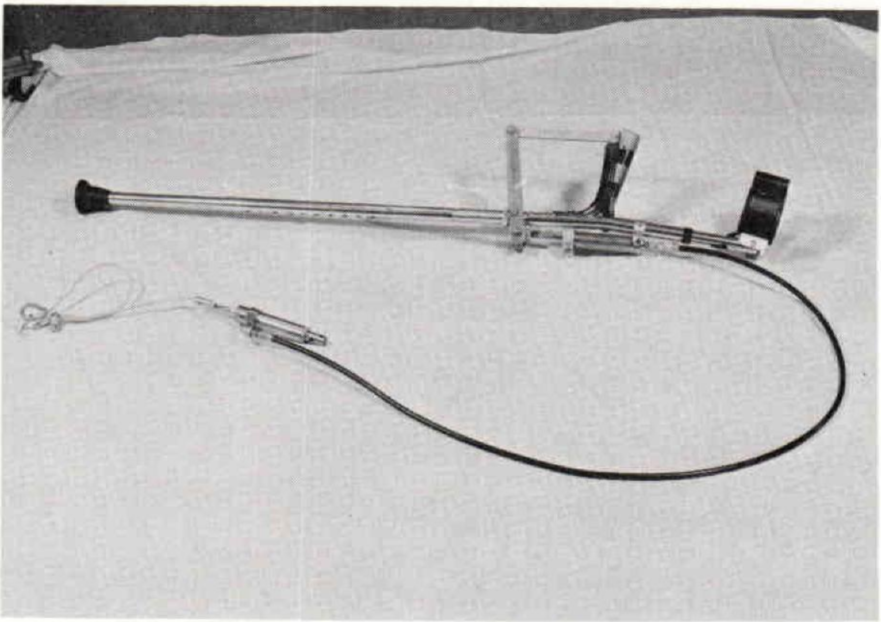

FIGURE 1—Downward pressure on the crutch handgrip results in movement of a piston into the master cylinder, directly linked to a slave cylinder by flexible hydraulic tubing. Improved models should have the master cylinder mounted inside the shaft of the crutch.

parts of the body to operate assistive devices. Control of internal power is easier to learn, and its use avoids the expense and inconvenience of recharging the storage batteries or the gas cylinders of an external power source. A common example is the use of shoulder flexion and protraction to power the terminal device of an upper-extremity prosthesis. Another use of internal power is found in the Hydra-Cadence prosthesis (4), where hip flexion provides power that is transmitted hydraulically from the passively flexing prosthetic knee and results in ankle dorsiflexion. Feasibility studies have been reported on the use of heartbeat and respiratory motions to power a cardiac pacemaker (5), and the compression of a piston in the shoe heel to power an upper-extremity prosthesis (6).

Description of Hydraulic Crutch

This paper is a preliminary report of efforts which began in July, 1967 to obtain internal power by means of a cylinder and piston mounted in a crutch. Figure 1 shows an experimental model of an aluminum forearm crutch fitted with a master cylinder whose piston is activated by leaning on the handgrip. Hydraulic fluid transmits the power directly to a slave cylinder that is attached to the body in a position where the piston motion can provide a useful force.

Figure 2 shows a pair of hydrau-

FIGURE 2—Paraplegic patient using two hydraulic crutches. To assist in performance of the four-point gait pattern, weight-bearing on the right crutch assists flexion of the left hip, and vice versa.

lic crutches whose slave cylinders flex the opposite hips and extend the knees of a paraplegic patient. This arrangement permits internal powered assistance in the performance of a four-point gait. Another application under study is in unilateral hip disarticulation, to assist flexion of the hip of a Canadian prosthesis.

DISCUSSION

Much additional developmental research is needed to make such a system practical. The optimum internal power device should have high efficiency to conserve the limited human power output; rapid response to deliver the power precisely when it is needed; ease of control so that natural gait movements will automatically trigger it; the capability to store power temporarily; and the avoidance of unnecessary up-and-down movement of the patient's center of gravity when activating the system.

The ideal internal power source for a hydraulic system would probably be a master cylinder and piston which *decelerated* an unwanted movement and resisted the entire weight of the body. For example, paralyzed quadriceps femoris function could be replaced by a cylinder whose piston motion would pressurize hydraulic fluid, thus resisting the tendency of the knee to buckle, while at the same time providing power which could be used elsewhere. An air pressurized hydraulic accumulator would be the most convenient component for power storage.

SUMMARY

Internal power for orthotics and prosthetics is discussed as an intermediate stage between external power and no power. Preliminary work is described on a hydraulic crutch as an internal power source. The requirements to make such a system practical are discussed.

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