A WRIST-POWERED HAND PROSTHESIS

T. DICK, D. W. LAMB, W. B. DOUGLAS

From Princess Margaret Rose Orthopaedic Hospital, Edinburgh

This paper describes a prosthesis for patients who have had a partial amputation of the hand, or who have congenital absence of all or part of the hand. The prosthesis incorporates a new concept whereby the grip is operated by flexion and extension of the wrist. A covering for the prosthesis has been developed using a silicone polymer which produces a lifelike flexible glove. Thirteen patients have so far been fitted with this type of prosthesis, which can give good function and cosmesis.

Until now there has been no suitable prosthesis combining active function and good cosmesis for patients with a partial hand amputation of the transverse metacarpal type (Fig. 1) or for those with congenital absence of the hand. In both varieties, radiocarpal movement is retained (Fig. 2); this movement is used to trap any object to be held between the stump and a plastic plate (Fig. 3).

The idea arose that this radiocarpal movement might also be used to move the fingers of an artificial hand. Such a prosthesis was made in the early 1970s in the orthopaedic bio-engineering unit of the Princess Margaret Rose Orthopaedic Hospital (Davies, Lamb and Simpson 1974). The amount of movement at the radiocarpal joint in the first patient was limited and the function was correspondingly disappointing. In addition, the covering glove was made from polyvinylchloride which lacking cosmetic appeal, is not durable, and is difficult to clean; the thickness and stiffness also hampered finger movement.

The situation changed dramatically with the advent of two major developments from the orthopaedic bioengineering unit. The first was the development of an artificial hand incorporating useful function (Kenworthy 1974); the second was the evolution of a cosmetic glove, the appearance of which was revolutionised by the use of silicone rubber.

Function of the prosthesis. The conventional artificial hand has a three-point pinch; this is not efficient for picking up and gripping objects firmly. The lateral type of movement of the thumb towards the fingers, often used by patients who cannot abduct and oppose the thumb normally, suggested to us a suitable design for the

---

Fig. 1
Partial amputation through the metacarpals.

Fig. 2
Movement at the radiocarpal joint.

Fig. 3
The volar plate in action.

---

T. Dick, MIMechE, MIProdE, MBES, Director, Bio-Engineering Unit
D. W. Lamb, FRCS, Consultant Orthopaedic Surgeon
W. B. Douglas, Medical Physics Technician
Princess Margaret Rose Orthopaedic Hospital, Fairmilehead, Edinburgh EH10 7ED, Scotland.

Requests for reprints should be sent to Mr T. Dick.

© 1984 British Editorial Society of Bone and Joint Surgery
0301-620X/84/5125 $2.00

THE JOURNAL OF BONE AND JOINT SURGERY

742
movement of an artificial hand. The fingers are positioned so that the index and middle fingers are flexed towards the palm, the middle finger being slightly more flexed than the index; so positioned, the fingers form gripping points against which the thumb can oppose (Fig. 4). Movement of the fingers is powered by the radiocarpal movement (Fig. 5).

When a normal hand is used for gripping, closing the fingers is associated with dorsiflexion of the wrist and release of the fingers with palmarflexion. This might be expected to apply also to an artificial hand operated by wrist movements, but several of our patients have preferred the opposite control, namely palmarflexion of the wrist to close the fingers and dorsiflexion to open them. The method of control can be varied according to the preference of the patient and any local points of tenderness in the stump. Figures 6 to 9 show an example of a prosthesis where the fingers are closed during palmarflexion and opened during dorsiflexion.

**Appearance of the prosthesis** (Figs 8 and 9). The usual

---

**Fig. 4**

The action of gripping will usually involve three contact points, shown here as 1, 2 and 3. When gripping long objects, a fourth contact point, marked 4, is introduced which helps stabilisation. Figure 5—Letters A, B, C and D indicate the pivot points of a parallelogram lever system which is operated by flexion or extension of the cap over the stump.

**Fig. 5**

**Fig. 6**

The mechanism of movement. Figure 6—With palmarflexion the fingers close. Figure 7—With dorsiflexion they open.

**Fig. 7**

**Fig. 8**

The cosmetic appearance is not displeasing. Figure 8—In palmarflexion. Figure 9—In dorsiflexion.
The appearance can be remarkably lifelike.

The mechanism for attaching the prosthesis.

method of dip moulding does not allow a glove to be made with flexed fingers; to overcome this difficulty a new technique using a female mould has been developed. This not only solves the problem of flexed fingers, but also allows accurate control of the thickness of the material. The material used in the cosmetic glove covering is a silicone polymer vulcanised at room temperature. During manufacture, the silicone polymer is added to a volatile solvent, the low viscosity of which allows the fine detail of the mould to be meticulously copied; this produces a lifelike flexible covering (Fig. 10). Furthermore, if the glove is built up in several layers, the correct flesh tone of the patient's skin colouring can be accurately reproduced.

Figure 11 shows how the prosthesis is attached to the stump. With this arrangement, the wrist is free to rotate and is only restrained in the movement of dorsiflexion and palmarflexion required to operate the hand.

Use of the prosthesis. We have fitted 13 patients with wrist-operated hands. Most have been in adults who, as the result of trauma, have lost a hand but retained radiocarpal movement. Two such patients are shown in Figures 12 and 13. The prosthesis is, however, also suitable for children with congenital amputation through the midcarpus or the metacarpus.

Our patients have been extremely pleased both with the function and with the appearance of their prostheses. These artificial hands are not difficult to make, but it is essential that each patient is fitted with a prosthesis accurately modelled to a cast of his stump; the design would not be suitable for mass production.

REFERENCES


