

MEETING THE CHALLENGE OF PARTIAL HAND AMPUTATIONS

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Amputation of a part of a hand may create significant functional limitations for the amputee that are difficult to ameliorate by either orthoses or prostheses. We have attempted to provide both function and cosmesis to many persons with partial hand amputations and have been confronted by a variety of patterns of amputations and many different vocational and avocational needs. To help us develop a logical approach to devices for partial hand amputations we have studied the losses and divided them into categories.

Loss of a portion of a hand occurs primarily through trauma. In Michigan, a mixed industrial and farming state, we frequently see partial hand amputations resulting from accidents with punch presses, metal shears, conveyor belts, meat grinders, corn pickers and threshers. Less commonly, explosions, bullets, shredders, and thermal injuries cause amputations; rarely are fingers and hands lost because of vascular disease and malignancies.

Traumatic amputation of a part of the hand in an industrial accident usually occurs along a straight line through the phalanges or metacarpals but may be at any angle to the line through the distal row of carpal bones. It may remove, spare, or partially involve the thumb.

Farm accidents are more often uneven at the amputation site due to the tearing, clawing or shredding action of farm implements.

Congenital skeletal deficiencies of the fingers and hand account for a small number of patients who seek hand prostheses. In these cases, the pattern of absence is also variable but usually quite different from that of traumatic amputation.

The outcome for each patient has been dependent first upon the level and extent of amputation

and then upon the expressed preference for either function or cosmesis plus specific requirements made of the device. An amputee who is interested predominantly in cosmesis should get what he wants and not have some more functional but less cosmetic device forced upon him. His present vocation and his avocational desires must be considered carefully. The device must always be designed primarily to meet the amputee's needs. If it is obvious that one device will not fulfill all his needs, but two or three will do so, several devices should be prescribed.

The primary purpose of this paper is to discuss devices which have been fabricated for persons with partial hand amputations.

We have found it helpful to divide partial hand losses into several categories. Our classification of partial hand amputations results in four categories (Fig. 1):

1. Transphalangeal, thumb spared.
2. Thenar, partial or complete.
3. Transmetacarpal, distal; thumb spared or involved.
4. Transmetacarpal, proximal; thumb spared or involved.



Fig. 1. Levels of partial hand amputation: 1. Transphalangeal; thumb spared. 2. Thenar, partial or complete. 3. Transmetacarpal, distal; thumb spared or involved. 4. Transmetacarpal, proximal; thumb spared or involved.

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TRANSPHALANGEAL AMPUTATIONS

Transphalangeal amputations usually involve the four fingers in similar or slightly varying degrees. Most often these patients need no device but they may desire cosmetic fingers. These can be fitted easily when at least half of the proximal phalanx remains for each finger. Cosmetic fingers may be held on by suction or by special adhesives. They can be cut from a cosmetic glove made for prosthetic hands or may be custom made. Occasionally such a person needs and desires additional function.

CASE ILLUSTRATION

A thirty-year old male lost the fingers on his right hand in an industrial accident involving metal shears. A portion of the proximal phalanx of digits two through five remained with good range of motion and strength at the metacarpophalangeal (MCP) joints. The thumb was spared. He was right dominant and wanted to continue to use tools with his right hand. However, the proximal phalanx of the fifth digit was considerably shorter than that of the second digit so power grip was not effective. A stainless steel orthosis with plastisol covering was designed and fabricated (Figs. 2, 3). The device was designed especially to provide power grip to hold a cutting torch, wrench and hammer (Fig. 4). The side MCP hinge moves freely and permits the strength

of the finger flexor muscles to flex the opposition bar and provide a satisfactory grip on handles and tubular objects.

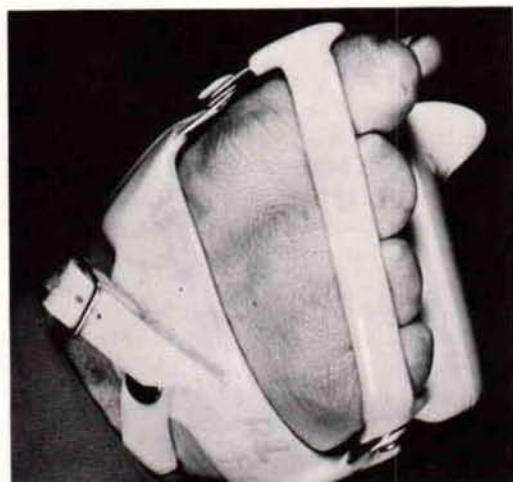


Fig. 3. Palmar view of orthosis designed to improve grasp for a person with trans-proximal-phalangeal amputation.



Fig. 2. Transphalangeal amputation of the second through fifth digits. Orthosis with dorsal metacarpal and phalangeal bars, side rivet pivot hinges at the MCP joint.

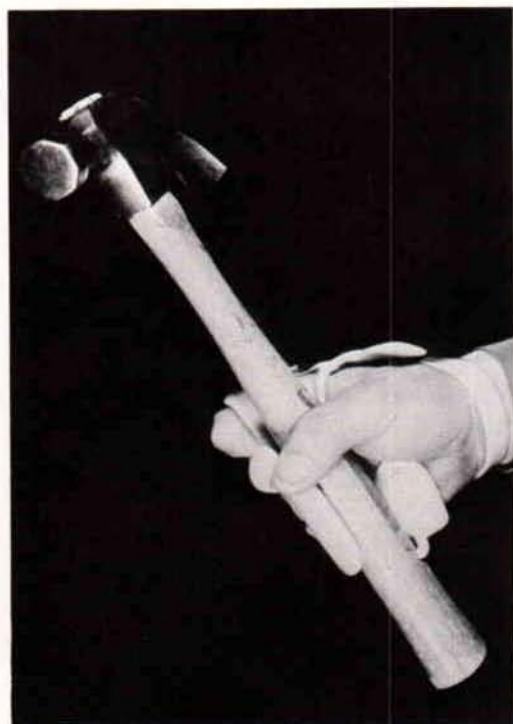


Fig. 4. Effective grasp of a hammer handle between thumb and orthosis.

THENAR AMPUTATIONS

Amputation of the thumb alone is relatively rare in our experience. When it does occur and involves the metacarpal as well as the phalanges, a prosthetic thumb can be made. Plastic laminates can be shaped to resemble closely a thumb and to provide a shallow socket that fits against the second metacarpal and is held on by either a Velcro or plastisol strap around the hand. If other digits adjacent to the thumb are amputated also, the prosthesis can be made with a wider socket and still provide a satisfactory prehension post (Figs. 5A and 5B).

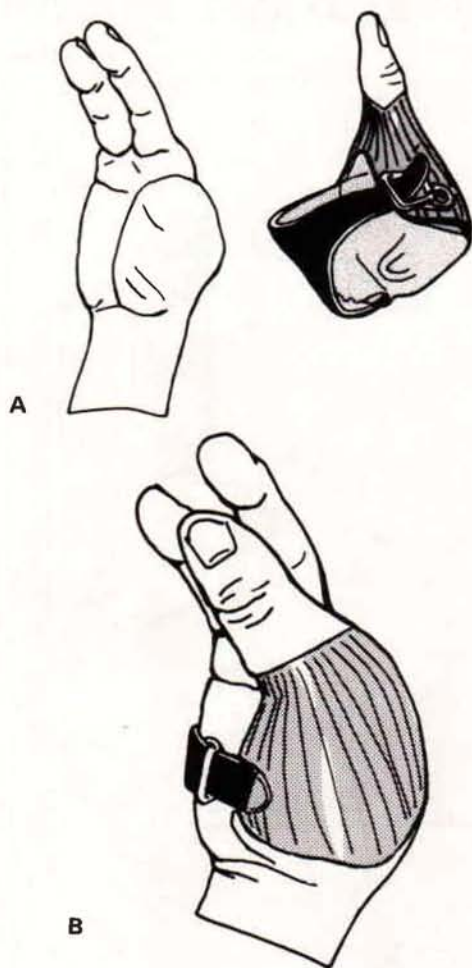


Fig. 5A. Amputation of the thumb, index, and middle fingers.

Fig. 5B. Prosthetic thumb fits over stump of metacarpals and straps to hand.

Congenital absence of the thumb occurs rarely and does not require replacement by a device. These children become very adept with the remaining digits and tend to use the index finger as a thumb. Surgical pollicization of the index finger generally appears to be unnecessary.

DISTAL TRANSMETACARPAL AMPUTATIONS

Amputations through the distal transmetacarpal area are quite common in our industrial location. Because most of these persons have been involved in strenuous occupations and probably will continue to do skilled and semi-skilled labor we must make stout devices for them. Some persons will wish a cosmetic hand in addition to a functional device. A custom made cosmetic hand is generally necessary; standard cosmetic gloves with fillers are not satisfactory.

Basically, two alternatives are available to the orthotist-prosthetist in providing functional devices for persons with distal transmetacarpal amputations. A prosthesis shaped like a mitt can be constructed (Fig. 6) or an open steel prosthesis can be designed to fill a specific need (Fig. 7).

The mitt prosthesis must be particularly strong in the distal portion. We recommend using six layers of glass cloth plus one layer of one-half ounce Dacron felt over a sheet of 0.080 inch thick stainless steel. The palmar area is lined with neoprene to provide friction. This prosthesis provides a large prehension area for gross activities such as lifting furniture (Fig. 8), and also permits finger tip prehension along the rim of the mitt. The rim is placed where the finger tips would normally be located. This prosthesis will withstand much abuse and is very practical for farmers and persons in laborious occupations.

Stainless steel prostheses are fabricated to the anatomy of each patient; they are not formed over a plaster mold or cast. Each piece is formed, fitted and silver soldered in place individually. To construct an opposition post for an amputation at the transmetacarpal level through the thumb and third, fourth, and fifth digits with only the entire second digit remaining one begins by shaping a palmar piece out of 0.050 inch thick stainless steel (Fig. 9). A steel rod is added from the palmar piece over the distal stump to the dorsal edge of the palmar piece. This rod prevents undesired

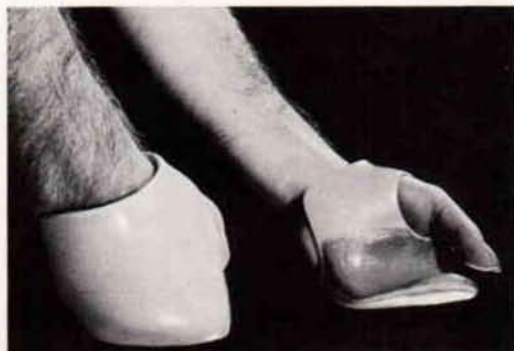


Fig. 6. Mitt-shaped prostheses for bilateral distal transmetacarpal amputations with sparing of the thumbs. (Reproduced from (1) by permission.)

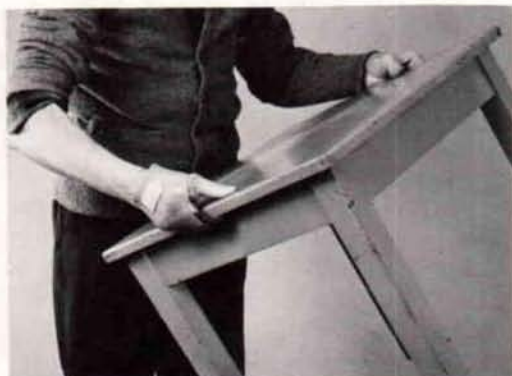


Fig. 8. A mitt-shaped prosthesis can provide adequate prehension force to lift heavy objects.



Fig. 7. Plastisol covered, stainless steel prosthesis for distal transmetacarpal amputation with loss of the distal phalanx of the thumb. (Reproduced from (1) by permission.)

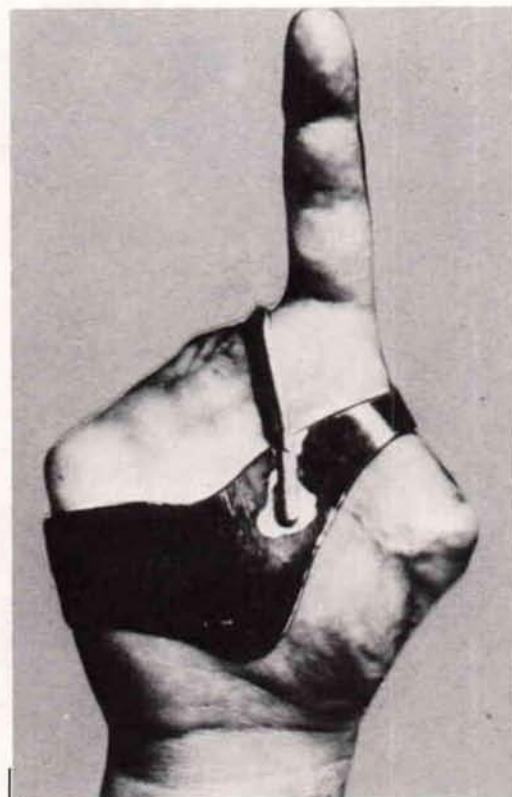


Fig. 9. Palmar piece shaped from stainless steel to serve as a foundation for an opposition post.

movement of the device proximally. The opposition post is then constructed and soldered in position (Fig. 10). Finally, a contoured steel plate is added over the end of the third metacarpal to avoid excessive pressure from the rod and the whole device is covered with flesh-tone plastisol by a dipping and curing process (2) (Fig. 11). A

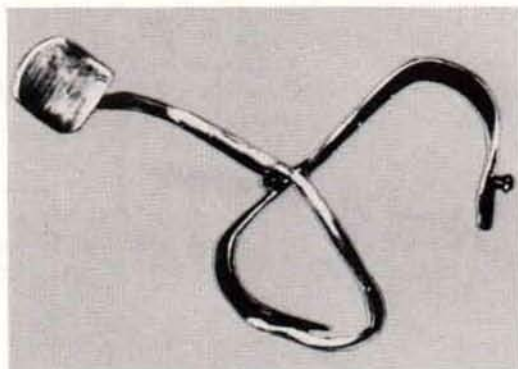


Fig. 10. Steel rod is placed over distal stump to prevent proximal migration of the prosthesis. Opposition post is soldered in position.

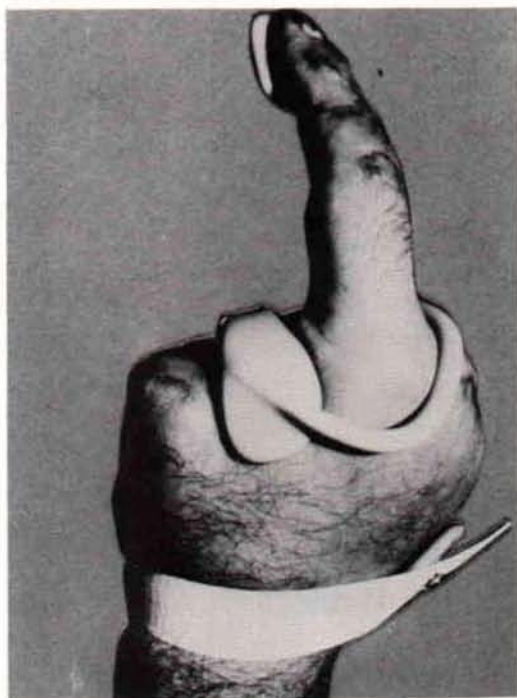


Fig. 11. Completed orthosis with plastisol covering and strap.

plastisol strap around the base of the metacarpals keeps the prosthesis from slipping off the hand distally.

Poor skin coverage of the amputation site is an unusual problem. Surgical techniques permit satisfactory skin coverage of distal amputation sites.

CASE ILLUSTRATION

A sixty-year old farmer lost all fingers including the thumb at the distal transmetacarpal level in a cornpicker machinery accident. Adequate skin coverage was not achieved because he did not permit additional surgery to cover the stump with skin graft (Fig. 12). The amputation site was quite sensitive and needed protection. He also desired function; he needed to grasp mechanical milkers firmly so he could attach them to his cows.

A stainless steel prosthesis was designed with a contoured piece of 0.050-inch stainless steel on the dorsal area which wrapped around the fifth metacarpal and stopped at the fourth metacarpal (Fig. 13). A small steel rod was positioned in the web space of the thumb for stability and to prevent proximal movement of the prosthesis. Stainless steel rods, 3/16-inch in diameter, were con-



Fig. 12. Amputation through the distal transmetacarpal area of digits two, three, four, and five with loss of the distal phalanx of the thumb. Skin coverage is inadequate for hand activities without protection. (Reproduced from (1) by permission.)

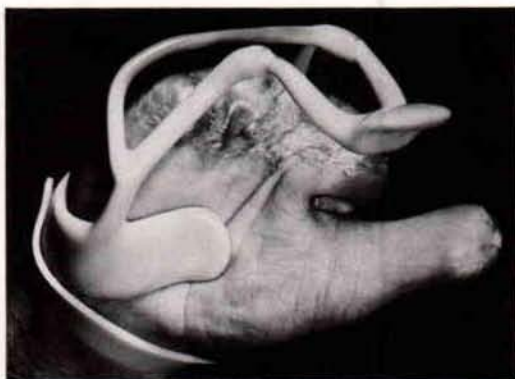


Fig. 13. Stainless steel prosthesis designed for hand shown in Fig. 12. It protects the amputation site and permits prehension. (Reproduced from (1) by permission.)

toured on the dorsal aspect and slightly distal to the sensitive amputation site to prevent bumping it, and to add strength to the unit. A second set of stainless steel rods were then positioned so that they would hold a semicircular opposition post in place. The post is silver-soldered to the rods at the appropriate angle to hold tubular objects such as milkers. Proper design and positioning of the post requires especially good judgement. One must consider carefully the length, range of motion, and strength of the thumb, as well as the size, shape, and weight of the objects to be picked up. Plastisol coating (2) provides a non-absorbent, resilient, pleasing appearance but the plastisol must be roughed up on the prehension surface of the opposition post to provide adequate friction for good function.

PROXIMAL METACARPAL AMPUTATIONS

The thumb may be spared, partially amputated, or absent in amputations through the proximal metacarpal area of the hand. Either cosmetic hands or functional devices or both may be used to restore appearance and function. The functional devices and, to a lesser extent, the cosmetic hands are more difficult to construct at this level of amputation because the short stump provides a less stable base. The device may need to extend above the wrist to gain stability or assist function.

CASE ILLUSTRATION

A twenty-nine year old female lost all fingers and the thumb on the right hand in a punch press accident (Fig. 14). A right-dominant person, she desired cosmesis and sufficient function to hold small objects and feeding utensils. Appearance of her hand was restored by a cosmetic plastic glove with semi-rigid fillers in the fingers and a zipper fastening on the volar aspect of the wrist (Fig. 15). An opposition post, similar to the one shown in Figure 11, was constructed with a short post to oppose the stump of the first metacarpal (Fig. 16). It provided the desired function.

In some traumatic amputations of the hand, damage may be done to proximal structures by the violence of the injury; the peripheral nerves and brachial plexus are particularly prone to such injury.

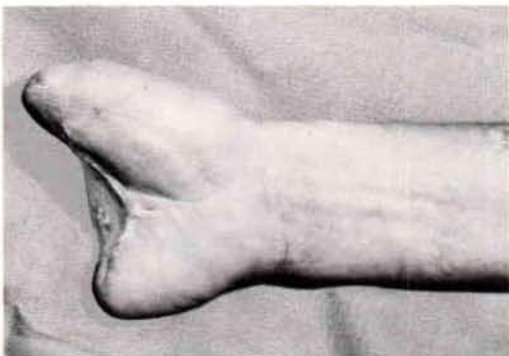


Fig. 14. Amputation through the proximal area of all metacarpals as the result of a punch press accident.

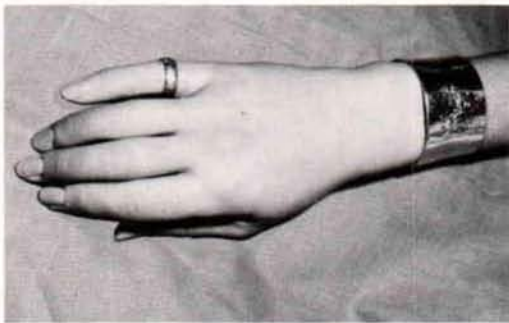


Fig. 15. Cosmetic hand and glove for hand shown in Fig. 14.

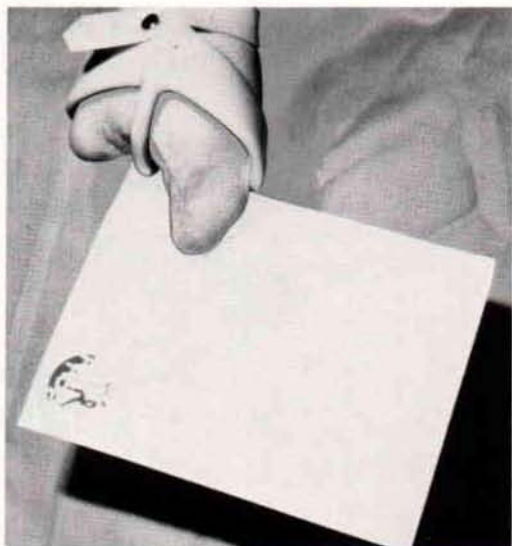


Fig. 16. Prosthesis with opposition post provides prehension for hand shown in Fig. 14.

CASE ILLUSTRATION

A twenty-five-year-old machine operator caught his left hand and clothing in a grinding machine that twisted his arm and mangled his fingers. The thumb was spared but all fingers were amputated and weakness of muscles supplied by the radial nerve below the elbow was noted. Wrist stability was added to a steel palmar band with opposition post by means of a plastic forearm cuff and 0.065-inch thick stainless steel straps along the radius and ulna incorporating single pivot hinges at the carpal level (Fig. 17). The hinges must be properly aligned with the axis of wrist flexion and extension. Teflon washers are used in the hinge joint to reduce friction. If wrist extension assist is needed, hooks can be soldered proximally and distally to the wrist joint on the dorsal side and rubber bands or springs used to provide the assistance. Spring tension is adjusted most easily by using rubber bands.

An alternate solution in proximal transmetacarpal amputations with an intact thumb is to fabricate an epoxy resin mitt similar to that shown in Fig. 6. To gain stability the mitt will usually have to encase the carpal area. It can be made sufficiently flexible, yet semi-rigid, so that it can be slipped over the stump and held in place with a single Velcro strap (Fig. 18). The rim of the

mitt can be made to any desired shape so utensils and small objects can be picked up as well as providing sufficient opening to grasp larger objects like an electric razor.



Fig. 17. Prosthesis designed to provide increased wrist stability and prehension between opposition post and thumb when all fingers are amputated but thumb is spared.

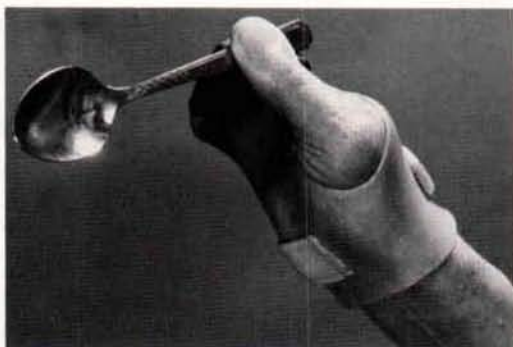


Fig. 18. Epoxy resin, mitt-shaped prosthesis for amputation of fingers at the proximal transmetacarpal area with sparing of the thumb.

CONGENITAL DEFICIENCIES OF THE HAND

Persons with congenital skeletal deficiencies of the hand, other than those with only the thumb missing, can sometimes be assisted by orthotic and prosthetic devices. The pattern of congenital skeletal deficiencies of the digits and rays of the hand is quite variable and even difficult to classify. The proposed International terminology for the classification of congenital limb deficiencies is helpful and those interested in orthotics and prosthetics should be aware of it (3).

CASE ILLUSTRATION

A twelve-year-old female with only one digit of the left hand, absence of a portion of the carpus and limited range of motion of the radiocarpal joint desired a new opposition device to replace a worn out volar splint. Active extension at the wrist was possible only to a neutral position but flexion was good. An opposition post was built so that fine prehension and large grasp were both possible (Figs. 19-22).

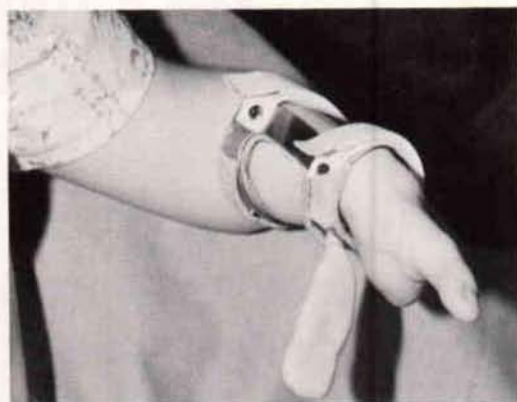


Fig. 19. Opposition platform for congenital skeletal deficiency of the left hand with only one functional digit and limited range of carpal motion.

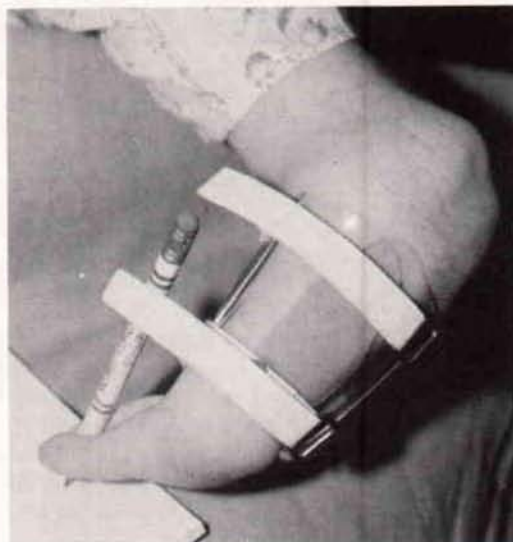


Fig. 20. Use of the opposition platform in writing.

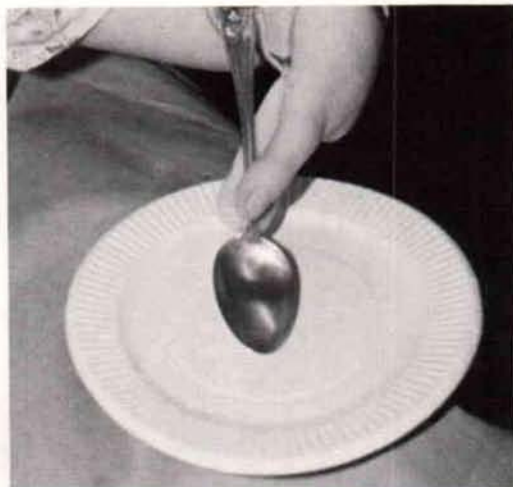


Fig. 21. Use of the opposition platform in eating.



Fig. 22. Use of the opposition platform in drinking.

CONCLUSION

By utilizing basic principles of orthotics and prosthetics and by exercising considerable ingenuity it is often possible to provide considerable improvement in function and/or cosmesis to individuals with partial hand amputations.

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