

Technical note

Creating a model for fabricating a partial hand glove prosthesis using the realigned casts of the contralateral digits

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Abstract

A method for creating a model for fabricating a partial hand glove prosthesis is described. The realigned casts of the corresponding digits of the contralateral uninjured hand were used to substitute for the lost digits on a cast of the stump. The technique allows an exact reproduction of the anatomical and fine surface details of the digits. It has the advantage of customisation, allowing a close match in the size, shape and surface characteristics of the prosthesis to that of the remaining digits of the hand.

Introduction

The first step involved in producing a custom fabricated prosthesis for aesthetic restoration of lost digits of the hand is to create a finger model from which an impression is made for moulding the prosthesis. Conventionally, the finger model is created by sculpting in wax to reproduce the skin details, size and shape of the lost digit using the cast of the corresponding digit of the contralateral uninjured hand as reference (O'Farrell *et al.*, 1996; Alison and Mackinnon, 1992; Buckner, 1992). However, when more than one digit is involved as in partial hand amputations, sculpting becomes time consuming. The method also requires the trained hands of a skilled sculptor and good results are not readily achieved.

The authors describe in this paper a method for creating a model for fabricating a partial

hand glove prosthesis. The realigned casts of the corresponding digits of the contralateral uninjured hand, with the skin details fully duplicated, are attached to a cast of the stump as substitution for the lost digits. The technique allows an exact reproduction of the anatomical and fine surface details of the digits. It has the advantage of customisation, allowing a close match in the size, shape and surface characteristics of the prosthesis to that of the remaining digits of the hand. Using this technique, the authors have fabricated and fitted prostheses to over 165 patients since 1990 (Leow *et al.*, 1997; Leow *et al.*, 1996; Pereira *et al.*, 1996).

Materials and method

Case example

Patients who sustain the loss of the digits of their hand are assessed for suitability for prosthetic fitting. The case example used in this technical note involved a 41-year-old male who sustained a machine injury to his right hand with loss of the ring and little digits at the level of the metacarpophalangeal joint (Fig. 1).

Impression taking

Impressions of the stump and of the digits of the contralateral uninjured hand which correspond to the lost digits were taken using dental silicone (Dent Silicone-V, Shofu Inc., Kyoto, Japan). Both hands were cast with the digits in the semiflexed and relaxed position. The impression moulds were reinforced externally with 2 layers of plaster of Paris to ensure structural integrity and filled with epoxy resin (Chemi R77N, Ciba-Geigy, Switzerland) which was then allowed to cure at room temperature (24°C). The skin details of the

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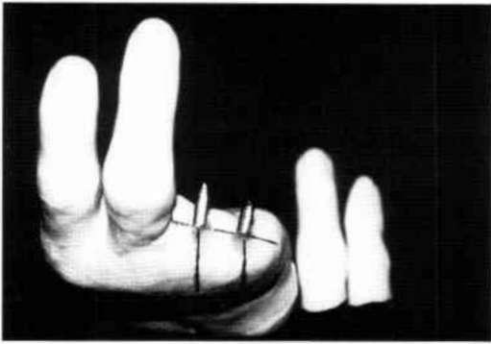


Fig. 1. The stump cast with the tapered screws implanted and showing the alignment lines drawn to guide the positioning and fixation of the finger casts.

contralateral digits would be exactly duplicated in the finger casts obtained from the impression moulds.

Alignment modification of the finger casts

The right and left hands are mirror images of one another. The corresponding digits of the right and left hands are invariably skewed in opposite directions – the tips of the middle, ring and little fingers are aligned somewhat radially while that of the thumb and index finger are oriented ulnarly when the hand assumes a relaxed position.

Before the finger casts can be used to substitute for the lost digits, some alignment changes are necessary. After allowing the resin to cure for 18 hours, the finger casts were withdrawn from the impression moulds. The resin had solidified but remained malleable at this stage. A light lateral bending force was applied manually (proximal and distal interphalangeal joints are fulcra) on the finger casts to produce the respective mirror alignment. The finger casts were “frozen” in reversed orientation by immersing them in cold water (4°C) for 1 hour. The tips of the realigned finger casts should be somewhat radially deviated when positioned on the stump cast to substitute for the lost digits.

Preparation of the stump cast for fixation of the finger casts

Two dorsal alignment lines were marked out on the stump cast along the location of the fourth and fifth metacarpals to guide the positioning of the realigned finger casts for fixation (Fig. 1). A lateral alignment line equally dividing the

thickness of the “palm” was marked on the ulnar aspect of the stump cast. A 10mm hole about 15mm deep was made at each digit at the points of intersection of, and parallel to, the alignment lines for implanting tapered screws (length 38mm) on to which the finger casts would be attached. The screws were implanted into the drilled holes and fixed with fast-curing resin (Araldite™ Rapid, Ciba-Geigy, Switzerland).

Fixation of the finger casts on the stump cast

The next step involved the positioning and fixation of the finger casts on the stump cast (Fig. 2). With the dorsal and the lateral alignment lines as guides, the appropriate position for the fixation of the finger casts was established. The location for drilling the holes into which the threads of the screws on the stump cast would go were mapped and marked out on the proximal base of the finger casts. The holes were made (bit size 7/32 inches) along the longitudinal axis of the finger casts following which they were “screwed” on to the stump cast. The orientation and the lengths of the finger casts in relation to the remaining digits were checked, making the necessary alignment changes to ensure conformity to the contour of the hand.

Bridging the defects between the finger casts and the stump cast

With the finger casts attached to the stump cast, the defects around the metacarpophalangeal joint area were bridged using plaster to restore the contour of the hand (Fig. 3). Skin details can be imprinted on these built-up areas using silicone impression of the corresponding



Fig. 2. The finger casts were securely attached to the stump cast after their orientation and lengths in relation to the remaining digits were adjusted to conform to the contour of the hand.

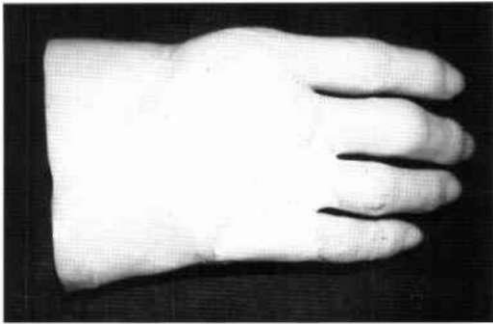


Fig. 3. The defects between the finger casts and the stump cast were "bridged" with plaster to restore the contour of the hand.

segment of the skin on the contralateral hand.

Fabrication and trial-fitting of test prosthesis

An impression of the completed model was made for the fabrication of a test prosthesis which was trial-fitted on the patient (Fig. 4). The test prosthesis was moulded in layers of silicone rubber, tinted but not matched to the patient's skin colour. In addition to anchorage onto the adjacent intact digit, the fixation of the prosthesis on the stump was augmented with the use of a skin adhesive. When an aesthetic appearance is achieved and the prosthetic fit is sufficiently secure, the final prosthesis can be fabricated and colour-matched to the patient's skin. The edge of the finished prosthesis can be trimmed and ground to taper at the proximal edges to flush and blend with the skin.

Discussion

A significant advantage of this technique is the exact duplication of the anatomical and the fine surface details of the digits. This allows the surface characteristics of the prosthesis to be closely matched to that of the remaining digits of



Fig. 4. The test prosthesis was trial-fitted on the patient to check the results before the final prosthesis was fabricated.

the hand. With the appropriate alignment modifications, the technique can be applied to cases of partial hand amputations involving the other digits, including the thumb. The technique is especially useful in cases of multiple-digit loss through the level of the metacarpals with no residual length remaining to allow individual digital fitting.

The realignment of the finger casts before they were used to substitute for the lost digits on the stump cast constituted a pivotal procedure of this technique. The choice of resin used (Chemi R77N, Ciba-Geigy, Switzerland) to cast the contralateral digits allows this alignment change to be effected. This resin has a slow and gradual curing process whereafter 16 to 18 hours, the material would have solidified but would still remain malleable, allowing bending and alignment changes.

The strength of this technique also lies in the exact duplication of the skin details of the contralateral digits with the use of silicone rubber as the impression material. The use of screws to attach the finger casts onto the cast of the stump has the benefit of allowing their orientation and lengths to be adjusted in relation to the remaining digits to conform to the contour of the hand.

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