

Aesthetic Life-like Finger and Hand Prostheses: Prosthetic Prescription and Factors Influencing Choices

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Abstract

This paper reviews the authors' experience with fitting life-like finger and hand prostheses. The methodology and technical considerations in producing these prostheses, the prosthetic prescription according to the level of amputation and the challenges faced with each level are discussed. In cases where the amputation is sufficiently distal, a thimble prosthesis has been used. This is compared to fitting a full-length finger prosthesis. Besides allowing free range of motion of the proximal finger joints which would otherwise be covered and restricted with fitting a finger prosthesis, a thimble prosthesis minimises skin coverage for optimal sensibility and is easier to don and doff. In cases of amputations where a digital fitting is precluded, a partial or a total hand is prescribed. A comparison between fitting a finger, a partial hand prosthesis and a total hand prosthesis is also discussed. Cases of a digital, transcarpal and a more proximal transmetacarpal amputations are relatively easy to fit with a prosthesis. An incomplete transmetacarpal amputation where much of the breadth of the hand is preserved presents a difficult challenge as it necessitates fitting with a partial hand prosthesis. Besides the need to cover a large area of the intact skin and the associated problems with reduced sensibility and stump perspiration, a partial hand prosthesis is difficult to don and doff.

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Introduction

Upper limb prosthetic developments worldwide have mainly been focussed on functional independence for the amputee. Surgeons and rehabilitation specialists strive to achieve greater range of motion in treating the injured hand. However, while aiming for optimal prehensile restoration, the psychosocial problems associated with disfigurement in the hand deserve due consideration.¹⁻⁹ The aesthetic function of the hand is easily taken for granted until after a person loses the physical form of the hand. In digital amputations, the emotional frustration experienced by the patient can be completely out of proportion to the functional deficit. A sense of not being looked upon as "normal" can exist throughout the patients' life and this can significantly affect emotional stability and self-esteem.

With rapid industrialisation in Singapore, incidents of finger and hand amputations are becoming a common occurrence. In the past, patients with these amputations would go without a prosthesis. Today, with rising affluence and the society becoming increasingly conscious of

their appearance, patients request for an improved cosmesis of their hand following a mutilating injury can no longer be lightly regarded. Fitting a prosthesis could be an option when surgical reconstruction cannot satisfactorily restore the form and appearance of the hand. Besides its psychosocial benefits, a prosthesis can assist hand function by restoring the length of amputated stumps thereby providing an opposable support for manipulation.^{2,4,9} Additionally, it can serve as a protective covering to a sensitive stump and encourage its use.

The authors have developed life-like finger and hand prosthesis made from a reinforced silicone rubber that circumvents the problems faced with the conventional polyvinyl chloride (PVC) prosthesis.^{8,9} Between 1990 and 1995, 165 patients have been fitted with these prostheses.

This paper reports our experience in fitting these prostheses—the challenges faced with each level of amputation and the solutions available. A good understanding of the stump requirements, the types of prostheses available, their advantages and disadvantages

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will allow the surgeon to better plan the surgery so that the best prosthesis can be fitted for each individual patient.^{1,5}

Fabrication and Fitting Methodology

Moulding

Each prosthesis is custom-made to be identical to the size, shape, skin details and colour of the lost part. A finger prosthesis is moulded from an impression taken from the corresponding finger of the patient's contralateral hand. Customisation in this manner also allows the patient to better identify with the prosthesis as his own.⁹ In bilateral digital amputations involving similar digits, impressions of the corresponding digits of a sibling or relative who closely match the patient's hand size, shape, and skin creases can be used. Similarly, a hand prosthesis is made from an impression taken from the corresponding hand of a sibling or a relative, if not, a close acquaintance. The impression mould of the hand is taken with the digits in a semiflexed position for a more natural appearance. The prosthesis is made using a technique of multilayered moulding after modifications to the master positive mould to match the alignment and the size of the stump had been done. A digital prosthesis takes approximately 5 working days to fabricate whilst a partial and a total hand prosthesis requires about 10 working days.

Colourmatching

A technique of colourmatching⁸ based on the multiplier anatomy and optical properties of the human skin¹⁰⁻¹² is used to achieve a life-like colouration of the prosthesis. The technique involves tinting the colour of each layer of the silicone rubber in varying shades. The outer layers of the prosthesis which correspond to the epidermis and superficial dermis were rendered translucent while the inner layers which correspond to the inner dermis and subcutaneous tissues were rendered opaque. To mimic the detailed colouration of the skin due to the differential pigmentation in the dorsal and volar surfaces, the finger joints, and the nail bed, a layer of touch-up colouration is "sandwiched" between the two layers.

Prosthetic Fitting

Fixation of the prosthesis onto the stump is achieved by a "suction cup" effect. To ensure a secure fit, the size of the prosthesis is made smaller than the size of the stump circumferentially. Otherwise, the thickness of the prosthesis can be increased by increasing the thickness of the inner layer, thus reducing the inner circumference. The elastic and nonporous prosthesis allows an airtight "cupping" of the stump so that an incipient displacement of the prosthesis distally produces a negative pressure within, creating a vacuum effect which

checks further displacement. Doffing of the prosthesis is achieved by allowing an inlet for the entry of air to diffuse the vacuum effect.

The hollow prosthesis is packed with a material comprising of silicone elastomer and polystyrene beads. The stiffness of the material can be varied to the individual need so that the functional potential of the prosthesis in providing a post for opposing with the remaining digits can be optimised.

Amputation Level and Prosthetic Prescription

The prosthesis prescribed for a patient depends on the level of amputation and the characteristic of the stump. As a rule, a digital fitting is always considered the first option. Only in cases of an absence or insufficient stump length involving more than one digit that a glove-type hand prosthesis will be recommended. A breakdown of the types of prostheses fitted to the 165 patients who sustained varying levels of amputation is shown in Table I.

Finger Prosthesis

Amputation through the proximal phalanx: For digital amputation through the proximal phalanx, a finger prosthesis is fitted to a level slightly distal to the interdigital web space. The proximal edge of the prosthesis is concealed with a ring which also helps to diffuse minor colour discrepancies between the prosthesis and the surrounding skin (Fig. 1). Seventy-two per cent of the patients were fitted with this type of prosthesis (Table I). Suitable candidates for digital fitting should have a well healed nonoedematous stump that is well aligned and be no shorter than 12 mm from the interdigital web space (Fig. 2).⁹ A short digital stump should be cylindrical in shape and not tapered or bulbous distally for a secure fit.

Thimble Prosthesis

Amputation distal to the mid-shaft of the middle phalanx: When digital amputation is sufficiently distal with the retention of the proximal or even the distal interphalangeal joint, a thimble or cap-type (Fig. 3) prosthesis is usually recommended. This is to avoid fitting across the finger joints. In this case, the proximal edge of the

TABLE I: A BREAKDOWN OF THE TYPES OF PROSTHESES FITTED ACCORDING TO LEVEL OF AMPUTATION

Type of Prostheses	Number of Patients
Finger	119 (72%)
Thimble	18 (11%)
Total hand	17 (10%)
Partial hand	11 (7%)
Total	165 (100%)



Fig. 1(a).

Fig. 1. A patient with amputation of the left index finger (a) before fitting and (b) after fitting with a full finger prosthesis. The proximal edge of the prosthesis is concealed with a ring.



Fig. 1(b)

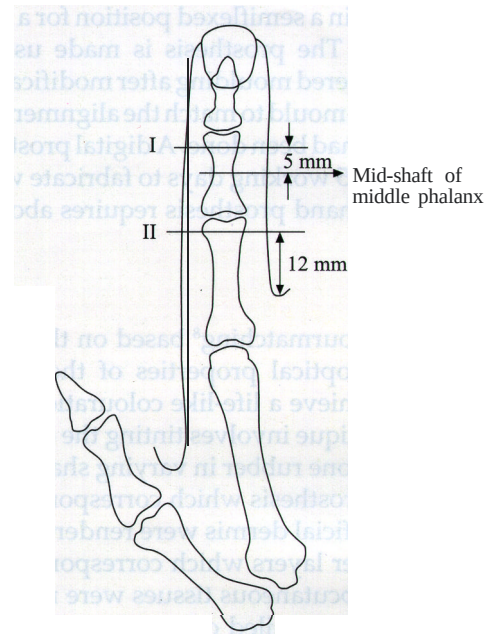


Fig 2 A schematic diagram delineating 2 levels of digital amputation of relevance to prosthetic prescription For a loss distal to level II, a full finger prosthesis is indicated For a loss distal to level I, a thimble prosthesis is usually recommended

prosthesis is distal to the finger joint but proximal to the mid-shaft of the middle phalanx. Given the stump is not too tapered distally and the soft tissue cover is not too loose, a minimum length of 5 mm distal to the mid-shaft of the middle phalanx is required for a good prosthetic fit (Fig. 2). In addition to the suction cup effect, a medical skin adhesive can be used on the stump for a more secure fit to prevent accidental slippage of the prosthesis. In our series, 11% of the patients were fitted with thimble prostheses (Table I).

Total Hand Prosthesis

Complete transmetacarpal or transcarpal amputation: In transmetacarpal or transcarpal amputations, a total hand prosthesis is fitted which provides complete coverage of the residual hand distal to the wrist. The proximal edge of the prosthesis at the level of the wrist is concealed with a wrist band or a watch. Ten per cent of the patients had a total hand prosthesis.

Partial Hand Prosthesis

Incomplete transmetacarpal amputation, oblique: In cases of incomplete transmetacarpal amputations where one

or two digits are intact either ulnarly or radially, a partial hand prosthesis is fitted. A partial hand prosthesis is defined as one which substitutes the lost digits and covers the residual hand distal to the wrist but exposes the intact digits for maximum range of motion and comfort (Fig. 4). In such cases, a full hand prosthesis is first made. The digits of the prosthesis corresponding to the intact digits of the hand are cut off at the proximal phalanx level to allow the latter to protrude and move freely. Rings are used to conceal the distal cut edge of the prosthesis.

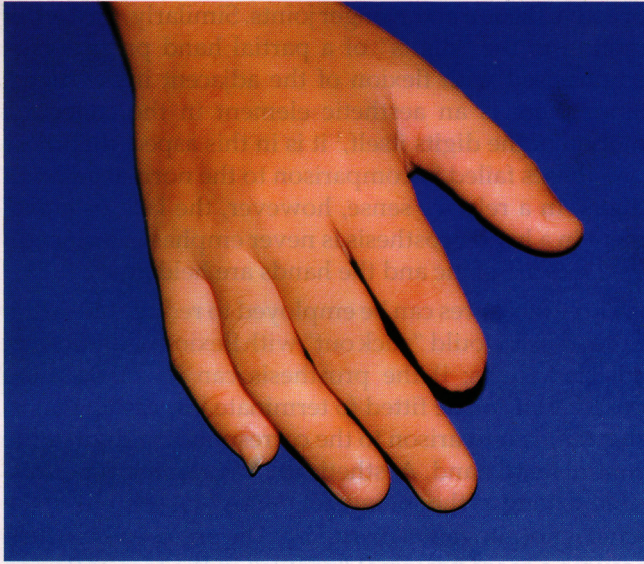


Fig. 3(a).

Fig. 3. A patient with amputation of the right index finger distal to the mid-shaft of the middle phalanx (a) before fitting and (b) after fitting with a thimble prosthesis. The proximal edge of the prosthesis is made very thin and translucent to flush and blend with the skin.

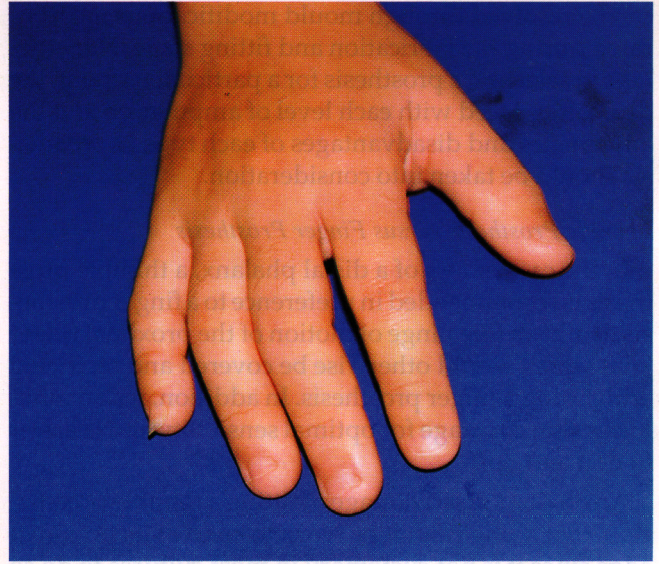


Fig. 3(b).



Fig. 4(a).

Fig. 4. A patient with an oblique tram-metacarpal amputation of the left hand post toe-to-thumb reconstruction (a) before fitting (b) after fitting with a partial hand prosthesis. The intact ring and little digits are allowed to protrude freely. The distal cut edges of the prosthesis are concealed with rings whilst the proximal edge is concealed with a sports band.



Fig. 4(b).

Incomplete transmetacarpal amputation, central: When the loss is central leaving an intact little finger and the thumb, a partial hand prosthesis is fitted which restores the loss index, middle and ring fingers but allows the intact digits to protrude through the prosthetic glove. Altogether, 7% of the patients sustained incomplete

transmetacarpal amputation (oblique or central) and had a partial hand prosthesis.

Selection of Type of Prosthesis

There are challenges and difficulties associated with each level of loss when fitting a prosthesis. Some of these

can be resolved through mould modifications incorporated during the fabrication and fitting stage. Nonetheless, in selecting a prosthesis for a particular patient, the difficulties faced with each level of amputation and the advantages and disadvantages of each type of prosthesis should be taken into consideration.

Thimble Prosthesis versus Finger Prosthesis

In the case of loss of a distal phalanx, a thimble prosthesis is recommended in preference to a finger prosthesis. It allows free range of motion of the proximal finger joint which would otherwise be covered and restricted with fitting a finger prosthesis. In addition, it also minimises skin coverage for optimal sensibility and is easier to don and doff.

An obvious disadvantage of fitting a thimble prosthesis is that a ring cannot be worn to conceal its proximal edge since it is not customary in most cultures to do so anywhere distal to the proximal phalanx. As a solution, the edge of such prosthesis is made thin and translucent to blend well with the skin. The prosthesis-skin juncture would usually go unnoticed since in the visual perception of familiar things around, we usually scan through, stopping only to focus on a particular spot when a gross abnormality is registered. Nevertheless, the prosthesis edge can still be picked up on close inspection, particularly by the patient himself as he may be overly concerned of its conspicuity and tends to focus on it. This is more often in the mind but it does influence behaviour. Thus, if the patient is so concerned, he may be better served with a finger prosthesis.

Finger Prosthesis versus Hand Prosthesis

Colourmatching demands: An important aspect in producing a prosthesis is to achieve a close colour match to the surrounding skin. A finger prosthesis and the “digits” of a partial hand prosthesis are positioned close to the normal adjacent digits. They lie within the same visual field of the eyes and are immediately subjected to comparison. In this respect, a finger and a partial hand prosthesis demand a highly accurate colour match to fulfil their role of aesthetic restoration. However, unlike the digits, a total hand can only be compared against the contralateral hand which are, in most instances, held apart. As the acuity of the eyes for visual comparison reduces with time and distance interval between two objects,^{12,13} slight differences in colour between a total hand prosthesis and the contralateral hand would be less apparent.

Limitations of prosthesis: A major limitation of a passive prosthesis lies in its inability for movement. In digital amputations through the proximal phalanx, the finger prosthesis depends solely on the metacarpal phalangeal joint for motion. Hence, when the hand makes a fist, the prosthesis “sticks out” conspicuously due to the absence

of active flexion at the finger joints. Similarly, the lack of motion in the “digits” of a partial hand prosthesis is emphasised with flexion of the adjacent intact digits. Since there is an aesthetic element in the concerted motion of the digits itself,* it is in this aspect that these prostheses failed in comparison to the normal adjacent digits. In a relative sense, however, the lack of movement in a hand prosthesis is never emphasised since all its digits are static and the hands are held apart.

Three measures can be employed to reduce the extent a prosthesis would “stick out” with flexion of the normal adjacent digits: i) the prosthesis can be made more flexed; ii) it can be fitted to terminate less distal, that is, shorter in comparison to the corresponding digit of the contralateral hand. Aesthetically, shortening is permissible so long as the somewhat pyramidal contour of the hand is not altogether disrupted. The prosthesis can then assume a more proximal “profile” in the face of flexion of the adjacent digits; or iii) the adjacent normal finger can be so positioned such that as it flexes, it pushes down the supple prosthesis into the palm. For instance, the ring finger can ride “piggy back” on the middle finger prosthesis so that both move in unified motion. This measure applies only to a single digit loss and would require some readjustments of manual functions by the patient.

Donning and doffing demands: A prosthesis for cases of a digital, transcarpal and a more proximal transmetacarpal amputation is easy to don and doff. However, in cases of incomplete transmetacarpal amputations (oblique or central) where much of the breadth of the hand is preserved, difficulty in donning and doffing arises. These cases necessitate fitting with a partial hand prosthesis which proximal edge must withstand stretch over the width of the residual hand and yet fit snugly around the wrist. The “zipper” technique, which is conventionally used with PVC prosthesis to overcome the problem, was not used in our silicone prosthesis. Instead, we employ a technique of enlarging the prosthesis around the “wrist” through modifying the master positive mould. This would minimise stretching when donning and doffing over the residual hand. A corollary of this method is “gapping” of the prosthesis around the wrist which we resolve by concealment with a wrist band. Talcum powder is used to facilitate donning and doffing.

Reduced sensibility and stump perspiration: As long as healthy skin is retained, the problem of reduced sensibility and stump perspiration exist with fitting a prosthesis. In this respect, a prosthesis should only cover as much of the stump to obtain a sufficiently secure fit. Thus, a thimble prosthesis is usually recommended for a long digital stump as it minimises skin coverage. However, in cases of incomplete transmetacarpal amputations, a large area of intact skin from the level distal to the wrist that

must be covered for anchorage would substantially reduce stump sensibility. In addition, extended hours of prosthesis use can potentially cause stump perspiration which may give rise to discomfort. The problem is inherent in the nonporous property of silicone rubber and can be compounded by the hot and humid climate of this region. If proper cleaning instructions are not observed, prolonged exposure to moisture added to the accumulation of sweat residues can lead to fungal growth in the prosthesis.¹⁴ However, the tendency towards perspiration in the stump would vary with each individual patient. In cases where perspiration in the stump was the cause of discomfort when donning the prosthesis, the use of talcum powder was advised and was sufficient.

Lifespan of prosthesis: Like all things, a prosthesis wears off with use over time. The main problems faced with the use of the prosthesis are wear of the surface layer of the prosthesis resulting in the loss of fine details, tear secondary to delamination of the silicone layers at the proximal edge and fingertip areas and a yellowing discoloration from exposure to the sun.^{8,9} The life span of a prosthesis depends on the frequency and the manner of its use. With daily use under normal conditions, the estimated life span of the prosthesis is about 2 years but can be prolonged with minor repairs as the need arises.⁹

Summary

A high quality prosthesis can restore near normal appearance and form of the hand. This can significantly repair damaged body image and simultaneously improve physical capability.⁹

Cases of a digital, transcarpal and a more proximal transmetacarpal amputations are relatively easy to fit with a prosthesis. An incomplete transmetacarpal amputation presents a difficult challenge as it necessitates fitting with a partial hand prosthesis. Besides the need to cover a large area of the intact skin, there are other problems of reduced sensibility and stump perspiration. A partial hand prosthesis is also difficult to don and doff.

Where indicated, a digital prosthesis should be considered as the first option in fitting borderline cases of digital stumps (which otherwise require a partial hand prosthesis) as it minimises skin coverage, is more comfortable to wear and easier to don and doff. When length is inadequate for a digital fitting, an interdigital web deepening or stump lengthening¹⁵ can be performed to obtain sufficient length. A partial hand prosthesis should only be prescribed when a digital fitting is precluded. However, a surgical revision to allow digital fitting

should only be done after clearly explaining to the patient the limitations of a prosthesis and the inconveniences associated with its use, such as the hassles of donning and doffing, the need for care and maintenance and the recurrent cost of replacement. A patient who has newly experienced the loss of a finger is only too eager to fit a prosthesis. However, after experiencing its limitations and with time, he may be better able to accept the loss and no longer need a prosthesis.

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