CASE REPORT

Aesthetic finger prosthesis with silicone biomaterial

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SUMMARY

The fabrication of finger prosthesis is as much an art as it is science. The ideally constructed prosthesis must duplicate the missing structures so precisely that patients can appear in public without fear of attracting unwanted attraction. A 65-years-old patient reported with loss of his right index finger up to the second phalanx and wanted to get it replaced. An impression of the amputated finger and donor were made. A wax pattern of the prosthesis was fabricated using the donor impression; a trial was performed and flaked. Medical grade silicone was intrinsically stained to match the skin tone, following which it was packed, processed and finished. This clinical report describes a method of attaining retention by selective scoring of the master cast of partially amputated finger to enhance the vacuum effect at par with the proportional distribution of the positive forces on the tissues exerted by the prosthesis.

BACKGROUND

The role of aesthetics is extremely important and plays a key factor in addressing the combined functional and psychosocial deficits experienced by individuals who are amputees. Finger and partial finger amputations are some of the most frequently encountered forms of partial hand loss. The causes of amputations can be are trauma, congenital absence and malformations. An average of one to two cases are treated half yearly with silicone prosthesis basically with vacuum-based type of retention.^{1 2}

Success of the prosthesis depends on the precision in planning, making the impression, carving the model and choosing the material that best suits the circumstances. Finger prostheses are challenging due to the stability and retention required. Individuals who are most dexterous suffer the impairment more. Though use of implants, adhesives and other material and methods are available, in this case report we tried to create a uniformly distributed positive pressure by selective rectification of the stump cast rather than uniform reduction. We obtained fairly good retention added by the use of the retentive finger ring due to lack of adequate surface area of the stump and were quite successful.

Here is a case report which describes a conventional method of fabrication of finger prosthesis, with a new approach or amputee finger modification for better retention and comfort. This write-up also gives comprehensive knowledge about the availability of various prosthetic materials and their uses in different clinical conditions.

CASE PRESENTATION

A 65-year-old man visited with a loss of right index finger up to the second phalanx and wanted to get it replaced (figure 1).

History revealed loss of the right index finger due to a sickle injury while working in the fields 6 months prior to presentation. On examination of the injured site there were no signs of inflammation or pathology. The wound was completely healed and was covered with healthy epithelium suitable for the fabrication of the prosthesis. The patient had no history of using any artificial prosthesis of any kind. An informed consent was obtained from the patient for the fabrication of the prosthesis under ethical standards.

TREATMENT

The patient was asked to thoroughly wash his hands under a plain antiseptic soap solution following which his hands were lubricated with a thin layer of petroleum jelly. An irreversible hydrocolloid impression material was used to make an impression of the amputated finger and was poured with American Dental Association (ADA) type IV dental stone (Kal Rock, Kala Bhai Karson Pvt; figure 2). The positive replica was used for the fabrication of the prosthesis. Another impression of the defected hand was made using irreversible hydrocollide impression material (Jeltrate; Dentsply) till to the wrist including the other finger were made in a completely resting phase and was poured with type III dental stone and was for characterisation of the prosthesis to provide a better life-like appearance.

The distal phalanx was manually palpated thoroughly for the amount of compressibility of the tissues and was indexed on the model of the amputated finger. Based on the compressibility of the tissues the model was reduced to 1–1.5 mm, greater being in the region of greater

Figure 1 Pretreatment.

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Figure 2 Alginate impression of the amputated finger.

compressibility. The reduction was accessed using vernier calliper. In addition, the stump was scored to form a ring-shaped depression of 1 mm and 1 mm width (figure 3) using round tungsten carbide burs close to metacarpophalangeal joint as possible.

An impression of the donor contralateral index finger was made using the irreversible hydrocolloid impression material and was poured with modelling wax. The wax pattern was retrieved and was modified and accessed on the complete hand model to gain a complete harmony with the rest of the fingers. Pattern was further surface characterised to mimic the soft tissue wrinkles, skin folds, etc using sculpting tools and was adapted on the stump mould (figure 4). The wax pattern along with the mould stump was flaked using ADA type III dental stone. The stone stump was indexed, relived of possible undercuts and was coated with a layer of separating media. Undercuts were avoided for easy opening of the flasks and for retrieval of the set silicone prosthesis. A three-piece mould space with retrievable stump mould for the packing of the prosthesis was created using the lost wax technique (figures 3, 5 and 6).

The medical grade silicone (Cosmosil HTV, UK) was mixed with the catalyst in the ratio of 1:10 and was mixed with thixo to thicken the material to reduce the air entrapment. The silicone was then proportioned based on the requirement of the material at various regions of the finger. Basic skin tone colour

Figure 4 Wax pattern of the amputated finger.

was formulated using basic skin colours following which skin shades were matched to specific regions using colouring pigments and solutions to the closest accuracy possible. Final colouration was achieved by eccentric staining procedure. The respective proportions of the silicone shades were later layered on the regions of ventral surfaces, dorsal surfaces, inter phalanx groves, etc (figures 7 and 8). The flasks were closed under light pressure, transferred to a clamp and the HTV silicone was processed under 100°C for 40 min as recommended by the manufacture. The silicone prosthesis was retrieved, trimmed and was finished using sharp scissors and finishing burs.

The fit and shade was evaluated on the patient. For better colour and shade matching the prosthesis was eccentrically stained in the presence of the patient under daylight. The finger nail was processed using acrylic resin and pigmented to match the patient nails. The prosthesis was inserted and additional retentive aid was provided in the form of a finger ring (figure 9). The patient expressed satisfaction with the end result of the prosthesis.

Figure 3 Stone model of the stump followed by scoring.

Figure 5 Ventral surface of the stone mould.

Figure 6 Dorsal surface of the stone mould.

Figure 8 Packing of the mould with silicon.

The patient was educated about the maintenance of the prosthesis. Home care included mechanical debridement of the skin around the prosthesis using soft tooth brush and lukewarm water irrigation with soap. The patient was evaluated after 4 months. The skin around the prosthesis was healthy, and the retention of the prosthesis was good.

OUTCOME AND FOLLOW-UP

Retention of the prosthesis was adequate. The patient expressed satisfaction about the same and the comfort during use due to selective distribution of the pressure on the stump. The patient follow-up was started for 1 year postinsertion regularly with 2 months interval. The patient showed no signs of discomfort and was satisfied.

DISCUSSION

Success of prosthesis depends on the precision in planning, making the impression, carving the model and choosing the material that best suits the circumstances. Issues that clinicians should attend to include: (1) amputation is a diverse disability; (2) discrimination by others; (3) self stigma; (4) feeling

vulnerable to victimisation and (5) the role of values, meaning and perspective in positive adjustment.^{1 3 4}

Material available for maxillofacial prosthesis are³⁻⁶ acrylic resin, acrylic copolymers, polyvinyl chloride copolymers, chlorinated polyethylene, polyurethane elastomers, etc.

Very commonly used materials include medical grade silicones, polymethyl acrylics, etc.⁶ Former being commonly used and preferred material for the mimicking the tissue structures and the consistency for a life-like appearance and the perception. Silicones are synthetic polymeric chains where silicone atoms bonded to organic groups typically methyl groups.⁷

Silicones are classified into four groups according to their applications⁴⁻⁶:

- Class I: Implant grade, which requires the material to undergo extensive testing and must meet Food and Drug Administration requirements.
- Class II: Medical grade, which is approved for external use. This material is used for fabrication of a maxillofacial prosthesis (used in our case).
- Class III: Clean grade.
- Class IV: Industrial grade commonly used for industrial applications.

Figure 7 Packing of the mould with silicon.

Figure 9 Finished prosthesis.

Various silicones available for maxillofacial prosthesis such as HTV Silicones, RTV Silicones, MDX 4-4210, etc.

We used HTV Silicones for fabrication of prosthesis. This is because of their outstanding properties over other silicone materials, which includes a wide range of service temperatures (–50°C to 200°C, or even –90°C to 300°C for special formulations), no known physical or physiological harmful effects, excellent ageing resistance, excellent thermal stability and stable colour. Of course, it has shortcomings such as not adequately elastic in function, low edge strength and opacity.⁶

Recently, some advanced silicone materials have become available for prosthesis such as silicone block copolymers, foaming silicones, etc which overcome the drawbacks of HTV silicones.

One should use a silicone finger prosthesis in conditions of amputation or congenital malformations of one or more phalanges with a sufficient residual phalange length of not less than 2 cm where direct fixations are possible. Silicone prosthesis are not indicated where the residual limb wounds are not completely healed, finger joint/wrist and residual limb end that are unable to bear weight, transcarpal residual limbs, unstable residual limb volume with fluctuations of more than 5%.⁸

A user's acceptance depends heavily on the ability to effectively represent the appearance and retention of the missing limb as well. During function active grasp is well-recognised as an important consideration when choosing prosthesis.^{9–13}

There are various methods to increase the retention of the prosthesis such as the use of retentive finger rings,^{14–15} medical grade adhesives,¹⁶ implants,¹⁷ etc along with the basic positive contact of the prosthesis with the tissues. Leow *et al*¹⁸ studied optimal circumference reduction of finger models for a good prosthetic fit of a thimble-type prosthesis for distal finger amputations and found out that 5–7% circumference reduction in the finger was shown to be best among 1–3% and 8–9% of reduction.¹⁸

In our article we rectified the stump mould to create a positive pressure and suction. The process of rectification was performed such that positive pressure was not localised but the pressure was distributed evenly and based on the capability of the tissues to withstand pressure rather than uniform reduction of 2 mm¹⁹ or 5–7% circumference reduction¹⁸ of the stump to create the passive vacuum fit. The retention was added also by a retentive finger ring which solved the purpose of retention and aesthetics.

Recent advances

In the present scenario intelligent dexterous prosthetic hands are developed which are capable of individual controllable fingers and thumbs which can abduct or adduct which allow implementation of many different grasping strategies. Smart Hand and i-LIMB are few of these highly sophisticated prosthetic hands available.^{19–21}

Today's technology permits fabrication of a finger prosthesis even in the absence of the physical presence of the patient. The research has been successfully carried out by Cabibihan²² and his team where computer-based design and fabrication of the prosthesis was performed to accurately replicate the patient's finger characteristics at the same time reducing the number of patient visits but the prosthesis fit was achieved by traditionally impressing the stump on stereolithography models.²² The cost and affordability by the patient limits the use to this technology.

Learning points

- ▶ Success of prosthesis depends on the precision in planning, making the impression, carving the model and choosing the material that best suits the circumstances.
- ▶ Acceptance of prosthesis depends heavily on its ability to effectively represent the appearance and comfort.
- ▶ In this technique, positive pressure was distributed evenly based on the capability of the tissues to withstand the compressibility and was added by a retentive finger ring which also solved the purpose of retention and aesthetics.
- ▶ Use of implants for the rehabilitation in this particular case would have been more appropriate keeping out the financial constraints due to a short stump.

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