

Flexible Foot Prosthesis: The Prosthodontics Way

Dr Ganesh Kamble, Dr Gilsa K Vasunni, Dr Neethu L, Dr Sameera K

I. Introduction

An amputation is the surgical removal of part of the body, such as an arm or leg. Leg amputations can be major or minor. Of the minor amputations, one of the most commonly performed is the partial foot amputation. PFA affects about 2 per 1000 head of population in industrialized countries making it the most common type of amputation surgery¹. Toe amputations are a very common level of amputation in patients with peripheral vascular disease, diabetes mellitus and post trauma. Apart from the psychological impact, toe amputation affects the gait and stance of the patient. Therefore, attempts must be made to maintain function and reduce force loading along the residual foot stump in order to reduce further skin breakdown and subsequent secondary limb loss in these patients. This goal can be attained by means of proper rehabilitation.

The first phase in rehabilitation is the physical rehabilitation. Rehabilitation begins with joint exercises, early mobility and muscle strengthening exercises. The patient is also educated regarding prosthetic restorations. The prosthesis can be divided into functional and non-functional. The non-functional prosthesis satisfy the aesthetic and psychological need of the patient without assisting in function.

The case reported pertains to a patient with toe amputations who was been rehabilitated with customized silicone partial foot prosthesis.

Case Report

A 40 years old male patient reported to the Department of prosthodontics, GDC Calicut with complaint of missing great and little toe of the left foot (fig.1). History revealed that the patient had met with a road traffic accident 2 years back following which he had to undergo amputation of the great toe at the level of distal phalanx and little toe at the level of metatarso-phalangeal joint.

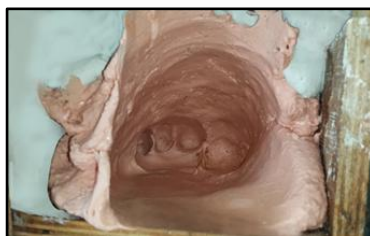
A complete medical history was elicited and the patient was found to be medically fit to undergo prosthetic rehabilitation. Various treatment options were discussed with patient and a treatment plan involving customized silicon foot prosthesis was finalized. An informed consent was obtained for the same.



(Fig.1)

Fabrication

Before starting with the clinical steps rough measurements of the patients unaffected feet were made. Using these measurements a wooden box was fabricated which was to serve as the custom tray. Patient's affected and unaffected feet were thoroughly cleaned. Alginate was mixed and loaded into the box. It was also simultaneously applied onto the patients affected feet ensuring proper coverage of the amputation areas. The patient was instructed to insert the foot into the box and maintain it in the weight bearing position till the alginate has set. Alginate impressions of the normal contra-lateral side were also made (Fig 2). The impression of the affected foot was poured in die stone to obtain a positive replica. Modeling wax was poured into the impression of the contralateral foot so as to obtain a wax model to guide the fabrication of prosthesis. The second impression of the contralateral foot, cast in dental stone was kept aside to aid as a reference in final wax pattern fabrication.



(Fig.2)

Fabrication of Wax pattern and Patient Try In

The big and little toe portions of the wax pattern was removed and aligned in the correct position on the working cast. The wax buildup was extended so as to form a sleeve extending upto half the length of the feet. The anatomy of great and little toe was modified so that it forms mirror image of the contralateral side(Fig.3). The wax pattern was tried on the patients feet while the patient stands erect. Any modification required in the morphology and fit of the prosthesis was done during the try in appointment.



(Fig. 3)

Once patient satisfaction was assured the finishing of the wax pattern was done. The portion corresponding to the nailbed was contoured and the margins undermined. The wax pattern was now ready for investing.

Creation of Mould Space

A wooden box is fabricated in two pieces with a sliding upper member. The dimension of the box was 8 X 8 X 6 inches. This box served as a customized flask. Separating medium was applied all over the working cast except on the wax pattern. Dental stone (Orthokal, Kalabhai, India) was mixed according to manufacturer's specification and poured into the custom flask. The working cast was placed into the stone ventral side first and immersed until only the wax pattern covering the dorsal surface is exposed above the stone.. After the initial pour had set, separating medium was applied over the stone portion and the counterpour was done with dental stone (Orthokal, Kalabhai, India). The lid portion of the box was slid into position. Once the stone had set dewaxing was done, the box was separated along the mould space. The mold surfaces were cleaned with diluted soap solution and placed under running tap water. Once the mold was sufficiently dried, soap solution was applied as a separating medium for the silicone material.

Packing of Silicone

Medical grade RTV silicon is used in a ratio of 10:1 and is mixed with primary colors such as red, blue and yellow. Master colors are then added until the skin shade of the contralateral foot and rest of the affected foot is obtained. Shade matching is done for both dorsal and ventral surfaces of the foot. The silicon is carried with a brush and coated on the respective surfaces. The remaining silicon is filled between the two halves of the mold, and the flask is approximated and tightened under a clamp. This flask and clamp assembly is allowed to polymerize at room temperature for 24 hours following which the flask is removed from the clamp and the prosthesis is retrieved from the cast. The prosthesis is cleaned with acetone before extrinsic staining is done. The excess material is cut with scissors and the margins of the cut ends are trimmed with silicon finishing trimmers. The prosthesis is tried on the patient's foot. Artificial nails were purchased, trimmed and attached to the respective nail beds.



(Fig. 4)

II. Discussion

Diabetes mellitus and peripheral vascular occlusive disease are major causes of toe amputation, but natural disasters and accidents also contribute to the number of people who have undergone amputation of toes. Single toe amputation does not usually affect a person's ability to walk. However, it can affect the position of the other toes, potentially causing deformities over time.

The hallux (big toe) plays an important role in stabilizing the medial aspect of the foot and the extensor hallucis longus (EHL) is one of the most important extrinsic muscles of the foot during the swing phase of gait². Therefore, amputation of the hallux frequently leads to an *apropulsive gait*³. The degree to which function gets affected depends on the level of amputation.

Loss of one or more distal phalanges of any toe has minimal effect on standing and walking but will deleteriously affect running as propulsion in late stance is slightly lessened. As the proximal phalanges are the site of insertion of plantar aponeurosis, its removal impairs comfortable standing especially for longer duration.⁴ Apart from these physical and structural effects there is also the psychological impact associated with any kind of amputation.⁵

Historically, a variety of prosthetic/orthotic modalities have been utilized to manage partial foot amputations. Among these devices, insoles, toe fillers, slipper sockets, ankle foot orthoses (AFOs) and clamshell sockets are the most commonly utilized prosthetic interventions⁶. Before 1984, partial foot prostheses were primarily rigid devices of conventional design fabricated from leather and metal or plastic laminate with a foam toe filler. These devices did not replace anatomical motion lost by amputation, but they did retain rollover in the toe section.⁷

The various prosthesis for PFA management available nowadays are of two designs- below ankle and above ankle. In the above ankle variety the dorsiflexion moment created by forefoot loading is easily resisted by counterforces generated on the heel and at the anterior brim of the device. This design also provides axial load relief in the event that full plantar weight bearing is contraindicated.⁸

More modern designs of prostheses of the slipper type enclose only the residuum and terminate around the ankle joint. In these designs resistance to the dorsi-flexion moment is provided by the accurate fit of the socket on either side of the calcaneus. These designs may be divided into the following categories: 1) rigid, 2) semi-rigid, 3) semi-flexible, and 4) flexible.⁸ The rigid and semi rigid variety utilize foam lining between the prosthesis and skin. The lining deteriorates rapidly and requires frequent replacement. The more newer systems belong to the flexible category.

For this patient a customized flexible silicone prosthesis was opted as the treatment plan keeping in mind the advantages of medical grade silicone and the inability of the patient to afford high end treatment options like implants or myoelectric prosthesis. Medical grade silicone in addition to the esthetics and life like feel also possess advantages like stability across varying range of temperature, flexibility even at -50°C, transparency, colourability using pigments, UV and ageing resistance and environmental compatibility.⁹ These materials can also be molded, and cured at room temperature.¹⁰

Silicone is also not abrasive when compared to the other materials used for prosthesis fabrication. Hence it causes less inflammation and tissue breakdown. The materials are biocompatible according to ISO 10993-1 and USP Class VI (selected tests), vapour permeable and easy to sterilize.⁹ However the technique sensitivity of silicone is a challenge. Hence precise processing and sufficient technical knowledge is a must when using this material.

The fabricated silicone prosthesis is self-retentive. It can be donned in the same manner as a socks or stockings. The margin between the feet and prosthesis was masked by using appropriate foot wear. Routine cleaning of the prosthesis using water and soap was enforced along with instructions for home care. For preserving the health of adjacent tissues, it was recommended to remove the prosthesis before going to sleep, in addition to washing the prosthesis receptor tissues with water and neutral soap or with a mixture of hydrogen peroxide and water.¹¹ The patient was recalled after 24-hours and was found to be comfortable with the

prosthesis. The tissue in contact with the prosthesis also appeared normal. The homecare instructions were reinforced. The patient was recalled in 1 week, 6 week and 3 month intervals. The patient was found to be adapting well to the prosthesis both physically and psychologically.

There is little consensus regarding the appropriate post-partial foot amputation rehabilitation modalities. Attempt must be made by the clinician to maintain function and to reduce loading of force along the residual foot stump so as to reduce further skin breakdown and subsequent secondary limb loss in these patients

III. Conclusion

The field of prosthesis fabrication for amputated patients is an area in which further researches are necessary. It is very essential to find a balance between the degree of functional rehabilitation to be achieved and the cost for providing the same. The clinician will always need to weigh various considerations including level of amputation and realistic functional expectations when deciding a specific prosthetic device for a partial foot amputation patient so that it maintains the highest level of function. The flexible silicone prosthesis using room vulcanizing silicone is a compromise, but definitely an acceptable compromise.

References

- [1]. Partial Foot Amputation: Aetiology, Incidence, Complications, Prosthetic Intervention and a Characterisation of Gait. Michael P Dillon, B. P&O (Hons); Ph.D. National Centre for Prosthetic and Orthotics Musculoskeletal Research Centre La Trobe University. Melbourne, Australia.
- [2]. A Guide To Digital Amputations In Patients With Diabetes Alexander Reyzelman, DPM, and Jamie Kim, DPM .Podiatry Today Volume 24 - Issue 9 - September 2011
- [3]. Hughes J, Clark P, Klenerman L. The importance of the toes in walking. *J Bone J Surg.* 1990; 72(2):245-251.
- [4]. Lower-limb Prosthetics and Orthotics: Clinical Concepts : Joan E. Edelstein, Alex Moroz p 79.
- [5]. Prim Care Companion *J Clin Psychiatry.* 2007; 9(4): 303–308.PMCID: PMC2018851. Reactions to Amputation: Recognition and Treatment Chaya G. Bhuvaneshwar, M.D., Lucy A. Epstein, M.D., and Theodore A. Stern, M.D.
- [6]. A Guide To Orthotic And Prosthetic Options For People With Partial Foot Amputations - Ryan Fitzgerald : Volume 26 - Issue 9 - September 2013.
- [7]. The Lange Silicone Partial Foot Prosthesis, Lawrence R. Lange, CPO. *Journal of Prosthetics and Orthotics* 1992; Vol 4, Num 1, p 56.
- [8]. Atlas of Limb Prosthetics: Surgical, Prosthetic, and Rehabilitation Principles Partial-Foot Amputations: Prosthetic and Orthotic Management ; David N. Condie, Melvin L. Stills
- [9]. Understanding Silicone, From Start to Finished Device. Camilla Andersson; *European Medical Device Technology*, June 2011, Volume 2, No. 6.
- [10]. Kanter JC. The use of RTV silicones in maxillofacial prosthesis. *J Prosthet Dent* 1970;24:646–653.
- [11]. Care and cleaning of maxillofacial prostheses. Goiato MC1, Zucolotti BC, Mancuso DN, dos Santos DM, Pellizzer EP, Verri FR. *J Craniofac Surg.* 2010 Jul;21(4):1270-3.