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Integrated Ankle Foot Orthosis (AFO) with Silicone Foot Prosthesis in the Management of Partial Foot Amputation - A Case Study

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ABSTRACT

Background: Partial foot amputation is the common type of amputation, due to vascular insufficiency, trauma, frostbite, limb deficiency, diabetes and its complications. Prostheses and Orthoses prescribed for partial foot amputations vary in design and principle.
Case Description and Methods: A 44-year-old woman who had traumatic transmetatarsal amputation 2 years ago. Post surgically the patient was treated with Reinforced silicone slipper type prosthetic foot for approximately 1 year. She was not satisfied with her prosthesis and felt severe pain in some parts of the residual limb, because of previous fracture on tibia and fibula. The Pain score was measured for immediately before the application of newly designed orthoprosthesis as well as after 4 months of regular use.
Results: The Pain score was decreased from 8 to 1 after using the newly designed orthoprosthesis for 4 months.
Conclusions: The newly designed Ankle Foot Orthosis (AFO) with Silicone Foot Prosthesis or Orthoprosthesis can be considered as a new alternative Management for Partial Foot Amputation
Clinical Relevance: This orthoprosthesis can effectively reduce the pain during ambulation as well as allows barefoot walking with excellent cosmetic appearance.

Key words: *Partial foot amputation, Silicone Prosthesis, partial foot prosthesis, Orthoprosthesis, Ankle Foot Orthosis*

INTRODUCTION

Partial foot amputations (PFA) are considered minor lower extremity amputations comprising a group of discrete surgical levels distal to the ankle. Partial foot amputation is the common type of amputation, due to vascular insufficiency, trauma, frostbite, limb deficiency, diabetes and its complications. [1, 2] Prostheses and Orthoses prescribed for partial foot amputations vary in design and principle. [3] Partial foot amputation prostheses can be divided into two categories: high-profile designs that extend onto the tibia up and low-profile devices that terminate inferior to the malleolus. [4] It seems that many individuals with partial foot amputations prefer to use the low-profile prostheses, specifically, flexible and semi flexible designs.

Cosmesis is very important aspect in the prosthetic management of amputation. After the implementation of silicone material in the field of prosthetics, the need of good cosmetic appearance to the artificial limb is almost fulfilled as the material can

be made as per the individual's skin color. Silicone prostheses that are flexible devices have a full-contact fitting on the residual limb. Silicone materials are also one more way advantageous like it feels like normal flesh when touched. So these materials are now days very widely used for the cosmetic restoration prosthesis. It is mostly used in upper extremity amputations like fingers, thumb or partial hand amputations. In some cases silicone is also used for the management of lower extremity amputation like toes and partial foot amputations, as there is a requirement of weight bearing & stability. This factor leads to the rejection of silicone prosthesis in lower limb amputations. The above said problem lead the foundation of the study to design and fabricate a prosthesis which can fulfill the requirements like weight bearing, stability and cosmesis in the prosthetic management of partial foot amputations.

Given the current state of knowledge, the aim of this study was to formulate an orthoprosthetic plan based on the anatomical knowledge for reconstruction of advanced prosthesis for the amputees with the Ankle Foot Orthosis (AFO) implanted inside the silicone foot, which would provide the toe break, stability/balance and cosmetically good matching with the normal skin.

A New Design

Over the past several years, we have been using a prosthesis that meets the functional requirements and one that also cosmetically acceptable. This prosthesis is designed similar to a silicone slipper type prosthetic foot except for the trim lines which are more proximal. It is the combination of an Ankle foot orthosis (AFO) with silicone slipper type prosthetic foot. The posterior portion of the socket extends proximally 4 inch above the malleoli. So, that it will provide more support to the distal part of tibial and fibula, patient will not fill any discomfort or pain during walking.

METHODS

Subject

The patient was a 44-year-old woman who had traumatic transmetatarsal amputation 2 years ago. She was referred to the Department of Prosthetics and Orthotics in the IIPO, Chennai, for the provision of suitable partial foot prosthesis. She was provided with Reinforced silicone slipper type prosthetic foot. She used this prosthesis for approximately 1 year. She was not satisfied with her prosthesis and felt severe pain in some parts of the residual limb, because of previous fracture on tibia and fibula. All the anthropometric data were collected from the patient. A detailed explanation of the study was given to patient. The patient gave informed written consent to participate in this study, and appropriate approval was also obtained from the ethics committee of the Institution.

Methodology

The pain felt during walking was recorded by an 11-point numeric rating scale. It consists of pain intensities which range from 0 to 10, reflecting an increase in pain. The numeric rating scale (NRS) is a segmented numeric version of visual analogue scale (VAS) in which the respondent selects the whole number (0 - 10integers) that best reflects the intensity of her pain. The common format is a horizontal bar or line. The patient indicated her level of pain based on this score.

Fabrication Procedure (Step by Step Fabrication Process)

1. Measurement:

First of all measurements were taken after the completion of the assessment. Profiles of both the residual and sound foot MTP and toes circumference were taken. Then the shape of the nail drew over the profile and color was checked on dorsal and ventral side with the color swatch. During the measurement time patient was advised to keep the foot in anatomical position.

2. Casting and Impression making:

Before starting any clinical procedures, two wooden boxes were fabricated by taking the

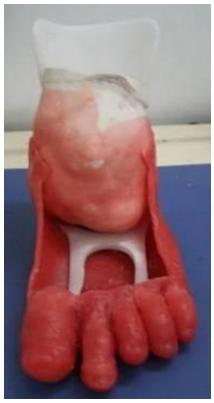
rough measurements of the patient's unaffected foot. Both the feet were cleaned properly before taking impression. Alginate was mixed as per the desired quantity and poured into the box. Then the patient inserted the foot into the box and maintained the weight bearing position till the alginate sets. Normal side impression was also taken by alginate. Special care was taken during the measurement process that the residual or sound limb should not touch the container. After impression taking process was over again two casts were taken of residual and normal side by Plaster of Paris (POP) bandage by the same conventional method of cast taking.

3. AFO fabrication:

POP powder was mixed with water to form a semi liquid which was poured into the POP negative cast and mandrel was inserted. Modification was done as per regular process. Then over the modified positive mould moulding process was done by melting the polypropylene sheet. The AFO then trimmed to a low profile posterior leaf spring design.

4. Silicone Prosthesis Fabrication:

Sound limb mould was filled (partially thickness with wax mould) in moulding wax. Residual limb mould was filled with stone plaster with a mandrel support. The stump mould was then dipped into hot wax, and formed a thin layer of wax all around the stump. The AFO was placed and then it was fixed with a wax referral cast over the stump and then followed with carving. During wax moulding process alignment was maintained. Seaming was done, followed with carving. Nail shape carving was made deeper.



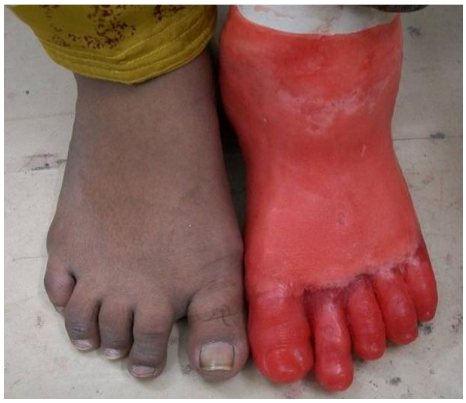


Figure 1: Cast of amputated limb and replica of sound side foot
Figure 2: AFO placed inside the foot
Figure 3: Patient with wax moulded partial foot prosthesis

A two piece mould was fabricated for the purpose to record the finer details. Both the moulds were separated after complete setting of the plaster. Then pattern was removed. Room Temperature Vulcanization (RTV) silicone was mixed and packed with the stained silicone. For 24 hours the mould was kept under compression, then mould was opened and the prosthesis was retrieved. The excess materials were trimmed and final finishing was done. Nails were made by silicone by packing clear silicone into the nail bed, and then stained silicone was layered on top to mimic the natural nail. Then gait training was given to the patient with and without foot wear.

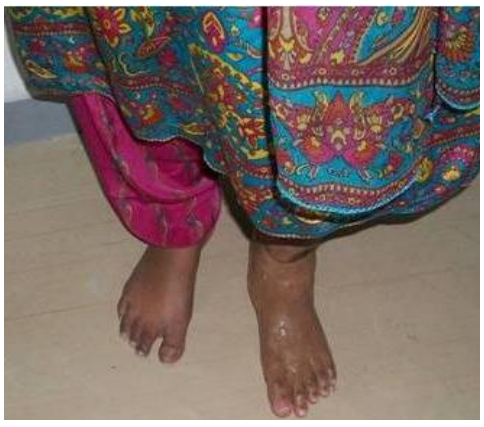


Figure 4: Patient with final product

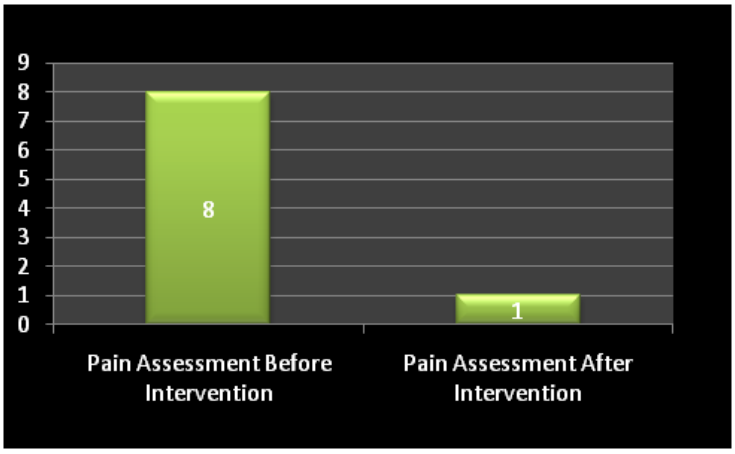
RESULT

Pain assessments were measured with 11-point numeric rating scale (NRS -11). Pain score 8 was found in pre-test which decreases to 1 after intervention of the newly designed Integrated Ankle Foot Orthosis (AFO) With Silicone Foot Prosthesis.

Table 1: Summary of clinical data

Subject	Age/Sex	Side of Amputation	Pain Assessment		Duration of use
			PABI	PAAI	
1	44 Years / Female	Left	8	1	4 Months

Abbreviations: PABI- Pain Assessment Before Intervention, PAAI- Pain Assessment After Intervention



Graph 1: Pain Assessment by NRS-11

DISCUSSION

A balanced foot is almost a necessity for successful fitting of any of the prosthetic systems. Trauma related amputations apparently do well with the slipper-type prosthesis, and the developer of the silicone system reports successful fitting in diabetic patients as well. The need for the prostheses to extend above the ankle appears to be limited to those patients with very short amputations, but successful fittings have been demonstrated with the slipper-type, sometimes using an ankle strap for suspension. [(3)]

In this design addition to the silicone foot plastic AFO is incorporated which provides stability, good toe break which further aids in push off during the terminal part of the stance phase. Here stability part is fulfilled by the plastic AFO and cosmetic part is done by the silicone foot. Now the combination of both fulfilled the desired function like stability and cosmesis. A significant advantage of this new silicone orthoprosthesis is providing patient satisfaction and reducing pain because of long lever arm. In this study, residual limb pain during walking with the new silicone orthoprosthesis was considerably reduced and the patient could walk more rapidly.

During the clinical trial patients found this design very much satisfactory as it provides a good base of support due to the rigid internal structure and cosmetically appealing from external appearance. This design is very well accepted by the patients because of its lower trimlines (as compared to normal AFO) as it helps in easy donning and doffing with this orthoprosthesis, bare foot walking is also possible as the foot appears like a normal anatomical foot. Barefoot walking aids another advantage is that it doesn't slip due to the physical property of silicone.

CONCLUSION

This design is an excellent choice for the partial foot amputees as it provides stability during the midstance allows toe break during terminal stance and also assists in pre-swing as well as allows barefoot walking with excellent cosmetic appearance. Best advantage is that it reduces pain during walking. It should be

emphasized that because of the limitations of this present study, the validity of this intervention should be reconfirmed by a large sample size and randomized clinical trials.

Conflict of Interest: The author does not have any conflict of interest regarding research, authorship and publication of this article.

Authors' Contributions: The entire clinical course of functional fracture bracing service delivery was done by Mrs. K C Sumithra towards the fulfillment of bachelor degree research project under the guidance of Mr. Surajit Kumar Sahu and Co-guidance of Ms. Minakshi Behera. The manuscript preparation is done by Ms. Minakshi Behera. All the clinical service delivery to patient and research study was carried out in the premises of IIPO, Chennai.

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