THE JAIPUR FOOT

DR POOIA MUKUL MD
REHABILITATION PHYSICIAN
TECHNICAL CONSULTANT
BMVSS, JAIPUR FOOT ORGANIZATION
&
CLINICAL DIRECTOR
CENTER FOR RECONSTRUCTION & REHABILITATION
JAIPUR
INTRODUCTION

- The JAIPUR FOOT is an original research product of Jaipur, INDIA.

- The foot was developed in response to specific socio-cultural needs of Indian Amputees, however, the design that evolved has features that make it suitable for use anywhere in the world.
To overcome this problem, a centre was set up in Jaipur, India.

Image by MIT OpenCourseWare.

Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India. Used with permission.
EVOLUTION

- JAIPUR centre started providing conventional lower limb prostheses.

- Rejection rates - HIGH
EVOLUTION

ANALYSIS OF REJECTION

The reasons were not technical OR biomechanical
BUT
Socio-cultural
The team at Jaipur centre realized that besides functional aspects, socio-economic and cultural demands of amputees needed to be addressed.
PROSTHETIC FOOT

- Look like a human foot
- Permit squatting
- Adapt to uneven terrain
- Should be waterproof
- Permit barefoot walking
- Permit use within footwear

- Should be affordable
- Should be made of locally available materials

Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India. Used with permission.
OBJECTIVES

1. It should look like a normal foot.

Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India. Used with permission.
2. The exterior should be water proof and durable.
3. It should allow enough dorsiflexion to permit the amputee to squat.
4. It should permit certain amount of transverse rotation of the foot on the leg.

Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India. Used with permission.
5. It should have sufficient range of inversion and eversion to allow the foot to adapt to uneven terrain.

6. It should be inexpensive.

7. It should made of locally available materials.

Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India. Used with permission.
EVOLUTION

SACH FOOT

TO

JAIPUR FOOT
SOLID ANKLE CUSHION HEEL (SACH)

Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India.
Used with permission.
JAIPUR FOOT

Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India.
Used with permission.
JAIPUR FOOT

- The JF is a non-articulated foot –ankle assembly.
- It consists of three structural blocks replicating normal foot anatomy.
- The forefoot & hindfoot are made of microcellular rubber and the ankle block is of light wood.
- These three blocks along with the toes are bound together by tyre cord and encapsulated in skin colored cushion compound.
- This structure is then vulcanized at 120 ° under 23 psi for 30 minutes.
JAIPUR FOOT

RANGE OF MOTION

Dorsiflexion : 20° - 35°
Heel compression : .8 mm to 2.8 mm.
Pronation : 26° - 29°
Supination : 15° - 22°
Axial Internal Rotation : 10° - 12°
Axial External Rotation : 4° - 8°
POST FITTING TRAINING

- Weight bearing surface
- Peer Training
Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India. Used with permission.
Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India. Used with permission.
Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India. Used with permission.
Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India.
Used with permission.
Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India.
Used with permission.
Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India.
Used with permission.
Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India.
Used with permission.
Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India. Used with permission.
Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India. Used with permission.
Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India. Used with permission.
Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India. Used with permission.
Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India. Used with permission.
Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India.
Used with permission.
Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India. Used with permission.
Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India. Used with permission.
Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India. Used with permission.
Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India. Used with permission.
Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India. Used with permission.
Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India. Used with permission.
Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India.
Used with permission.
Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India.
Used with permission.
Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India. Used with permission.
Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India. Used with permission.
Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India. Used with permission.
Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India. Used with permission.
Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India.
Used with permission.
Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India.
Used with permission.
Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India. Used with permission.
Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India.
Used with permission.
Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India.
Used with permission.
Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India.
Used with permission.
Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India. Used with permission.
Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India.
Used with permission.
JAIPUR FOOT : Biomechanical Analysis

A comparative study was conducted by Klenerman et al at Liverpool, U.K.

Two shock absorption variables -
  Impact Peak Force
  Impact Load Rate

Four gait style variables –
  Propulsive Force Peak
  Support Impulse
  Braking Impulse
  Propulsive Impulse were studied.
The study concluded –

“The performance of the Jaipur Foot is more natural and nearer to the normal foot as compared to the SACH and Seattle Foot.”
INTERNATIONAL STANDARDS

ISO-10328

VETERANS ADMINISTRATION PROSTHETIC CENTER STANDARDS FOR FOOT & ANKLE ASSEMBLIES
STATUS OF JAIPUR FOOT

DOES NOT WHOLLY CONFORM TO INTERNATIONAL STANDARDS
ACCEPTANCE IN THE DEVELOPED WORLD

UNACCEPTABLE

CRAFTSMANSHIP & FITTING – POOR IN 86%
PATIENT ACCEPTANCE – 94%
HOW ILLOGICAL / CONTRADICTORY!
INTERNATIONAL ACCEPTANCE
DEVELOPING WORLD

Afganistan
Bangladesh
Dominican Republic
Honduras
Indonesia
Malawi
Nigeria

Nigeria
Nepal
Kenya
Pakistan
Panama
Philippines
Papua New Guinea
<table>
<thead>
<tr>
<th>Rwanda</th>
<th>Somalia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sudan</td>
<td>Mozambique</td>
</tr>
<tr>
<td>Trinidad</td>
<td>Columbia</td>
</tr>
<tr>
<td>Vietnam</td>
<td>Sierra Leone</td>
</tr>
<tr>
<td>Zambia</td>
<td></td>
</tr>
<tr>
<td>Zimbabwe</td>
<td></td>
</tr>
</tbody>
</table>
‘People who live inside the World’s many war zones from Afghanistan to Rwanda may never have heard of New York or Paris but they are likely to know a town in northern India called Jaipur. Jaipur is famous in strifetorn areas as the birthplace of an extraordinary prosthesis or artificial limb, known as the Jaipur foot, that has revolutionized life for millions of landmine amputees. The beauty of the Jaipur foot is its mobility – those who wear it can run, climb trees and pedal bicycles – and its low price.’
COUNTRIES AWAITING ASSISTANCE

- Iraq
- Haiti
- Sri Lanka
- Chechnya
- Fiji
- Turkov
- Senegal
THE JAIPUR FOOT WAS DEVELOPED IN 1968.

RESEARCH HAS BEEN ONGOING TO IMPROVE ON THE DESIGN.

SOME ASPECTS THAT STILL REMAIN TO BE ADDRESSED ARE:

1. JAIPUR FOOT IS NOT AVAILABLE IN INTERNATIONAL STANDARD SIZES.
2. JAIPUR FOOT IS NOT COMPATIBLE WITH DESIGNS OF WESTERN LIMBS.
3. JAIPUR FOOT IS HEAVIER THAN THE SET INTERNATIONAL STANDARDS.
4. JAIPUR FOOT STILL DOES NOT COME WITH QUALITY ASSURANCE CERTIFICATION.
JF : CONVOLUTION IN RESEARCH

DESIGN OF THE JF HAS STOOD THE TEST OF TIME.

HENCE

ALL RESEARCH HAS TOGYRATE AROUND THE BASIC STRUCTURE & ITS FUNCTIONAL CHARACTERISTICS.
FUTURE COURSE

- SIZING THE JAIPUR FOOT TO MEET INTERNATIONAL STANDARDS LAID DOWN BY THE VETERANS ADMINISTRATION PROSTHETIC SERVICES, NEW YORK.
- DESIGNING THE JAIPUR FOOT TO BE COMPATIBLE WITH THE WESTERN PROSTHETIC DESIGNS.
- MATERIAL MODIFICATIONS TO REDUCE WEIGHT AND INCREASE DURABILITY.
- STANDARDIZING TESTING EQUIPMENT FOR QUALITY ASSURANCE.
BMVSS SURVEY - Patient acceptance rate of Jaipur Limb - 98.7%

Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India. Used with permission.
Jaipur Foot & Limb Technology

ISPO Retrospective Study  Patient acceptance rate of Jaipur Limb- **94%** (JPO Volume 28  No.3)

Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India.

Used with permission.
FINAL WORD

USER REACTION & USER ACCEPTANCE
THANK YOU
BMVSS- As an organization

- Established in 1975 at Jaipur
- 19 Centres across the country
- Open door and patient friendly policy
- Delivery System
- Free assistance not charity
- Academic activities
- R&D
BMVSS- Achievements

- Provided 59 prostheses in the first year of its inception.
- Today provides more than 20 thousand prostheses in a year (largest limb fitting centre in the world)
- Total beneficiaries are > 1.1M
Jaipur Socket History

- Aluminum Sockets
- HDPE Sockets
- Total Contact Sockets
First Phase- Aluminum Sockets

Aluminium Sockets (1968–1987)

At that time

- the demand was huge,
- services were limited
- lack of trained manpower
- lack of materials
- non-availability of any other suitable technique
- huge resource of artisans having traditional knowledge of technology

Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India.
Used with permission.
First Phase- Aluminum Sockets

Aluminium Sockets (1968–1987)

- ease of Fabrication
- able to withstand climate changes
- easily available in the local market

Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India.
Used with permission.
First Phase- Aluminum Sockets

Aluminium Sockets (1968–1987)

The combination of Jaipur Foot and Aluminum socket:

- Really filled the void and became very popular
- Was a cross breed of standard PTB and conventional plug fit sockets

Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India. Used with permission.
First Phase- Aluminum Sockets

Aluminium Sockets (1968–1987)

- This cross breed design suited to amputees in Indian climatic conditions
- Could be fabricated in an hour
- Delivery time was reduced significantly

Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India. Used with permission.
First Phase- Aluminum Sockets

Aluminium Sockets (1968–1987)

- This lead to unprecedented rise in the number of prosthetic fitment
- And Lowering of cost

Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India.
Used with permission.
Second Phase-HDPE Sockets

High density polyethylene (HDPE) pipes have the properties of:

- high impact strength
- high flexural strength
- high fatigue strength
- are inert
- withstand climate changes
- easy to handle
- good moldability
- available in the market

Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India.
Used with permission.
Second Phase-HDPE Sockets

HDPE Open Ended Sockets (1987-1995)

- using conventional POP wrap cast technique
- seamless
- light in weight
- fabrication time < one hour
- cost-effective material

Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India. Used with permission.
Third Phase – Total Contact

Total Contact Sockets (1995 – continuing)

- using conventional POP Wrap cast technique
- inner socket was made of HDPE or PP Co-polymer sheets

Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India. Used with permission.
Jaipur Foot & Limb Technology

In-process alignment technique to incorporate the total contact socket with shank

Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India.
Used with permission.
Alignment Transfer technique is also used to align the inner socket with shank

Courtesy of Dr. Pooja Mukul, Bhagwan Mahaveer Viklang Sahayata Samiti - Jaipur Foot Organization, Jaipur, India.
Used with permission.
Standards

- International Standards known as ISO:10328
- Indian Standards known as BIS Standards
ISO:10328

- These standards were developed in collaboration with ISPO and are very rigorous and strict.
- Do not take care of normal human requirements and meant for specific Prosthetic feet.
- Testing Load is applied only at forefoot and heel.
- No dorsiflexion, inversion or eversion.
ISO:10328

- In an recent article published by ISPO, the authors have observed that lab test as per ISO :10328 showed little wear to the foot sole
- We should develop our own standards considering the gross physical, social and cultural needs of our people.
- And standards should be such that even other countries should copy them
BIS Standards – Prosthetic Feet

- At present there are no standards available for prosthetic feet in India
- Draft standards for SACH foot are in circulation for comments
- We have applied to BIS to formulate standards for Jaipur Foot
BIS Standards – Sockets

Sockets are custom made
BIS Standards – Calipers

- The standard for calipers is very old
- Thermoplastics are being used extensively and proving very effective
- Standards should be revised in accordance with the gross requirements of our people
BIS Standards – other aids

- BIS standards for tricycle, wheelchairs, crutches and other items are very strict and good.
- Scope of customization should be there to enhance the effectiveness of assistive devices
In the end, our congratulations and thanks to BIS for developing standards for prosthetic and orthotic and rehabilitation aids and appliances.

And revising them from time to time.
EC .722 Special Topics at Edgerton Center: Developing World Prosthetics
Spring 2010

For information about citing these materials or our Terms of Use, visit: http://ocw.mit.edu/terms.