TRANSFEMORAL PROSTHESIS

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Overview

Millions of amputees require above-knee prostheses. Many non-government organizations like Ratna Nidhi Charitable Trust fabricate and supply these to poor patients. They needed to improve the fitment using patient-customized sockets, and yet reduce the overall lead time.

As an intern at BETIC, IIT Bombay where the project was taken up, my work included the design of the measurement sheet, generation of stump models using field data, comparison and validation of the developed parametric model, fabrication and assembly of prostheses.

Team

Lalit Amrutsagar (Lead Researcher)
Arvind Bhallamudi (Intern)
Viren Dhumal (Intern)
Dr. Trimbak Kawdikar (Physiotherapist)
Dr. Rupesh Ghyar (Project guide)

The project was supported by Google. It also involved IIT Madras (for knee joint) and MGM Hospital (for gait study).

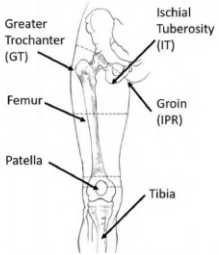
Problem Scenario

India has a large number of trans-femoral (above-knee) amputees who need high-quality yet affordable prostheses to return to near-normal life.

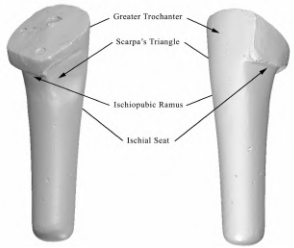
Current low-cost prostheses such as 'Jaipur Leg' use a plaster replica of the residual limb of patients to fabricate a matching socket. Stump replication is a cumbersome process that requires skilled technicians, challenges the dignity of patients and often requires rework.

Research on Conventional Prosthesis

Difficult to fabricate and has a locked knee joint



Weight bearing regions are GT, IT and IPR



The plaster stumps are 3D scanned for analysis

Design Goal & Requirements

Patient-customized above-knee prosthesis with better conformance and shorter fabrication time (compared to conventional Jaipur Leg)

Streamlined

Reduced skill and effort to measure patient stumps.

Conforming

Better fitment of designed socket with patient stump.

Throughput

Efficient fabrication process to increase the production.

Affordable

Suitable for large scale deployment and use by NGOs.

User Study and Method

Observing and interviewing patients in the conventional prosthesis making process in measurement and donation camp at Satara.

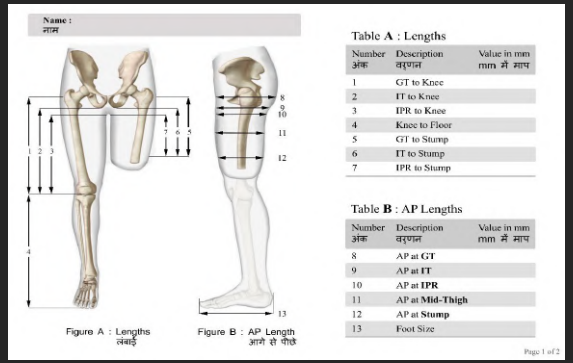
21 dimensions identified in discussions with clinicians and technicians, to semi-automatically generate a parametric stump model for patients.

We also tried generating the stump model by 3D scanning but this method had limitations in accuracy as well as logistics.

Measurement Chart Design

To facilitate proper measurements and their recording by field workers, an intuitive and bilingual chart was designed.

These measurements will be used to parametrically generate a CAD model of the patient's stump, which can be used to fabricate a socket.



Name :
नाम

Figure A : Lengths
लंबाई

Figure B : AP Length
आगे से पीछे

Table A : Lengths

Number अंक	Description वर्णन	Value in mm mm में माप
1	GT to Knee	
2	IT to Knee	
3	IPR to Knee	
4	Knee to Floor	
5	GT to Stump	
6	IT to Stump	
7	IPR to Stump	

Table B : AP Lengths

Number अंक	Description वर्णन	Value in mm mm में माप
8	AP at **GT**	
9	AP at **IT**	
10	AP at **IPR**	
11	AP at **Mid-Thigh**	
12	AP at **Stump**	
13	Foot Size	

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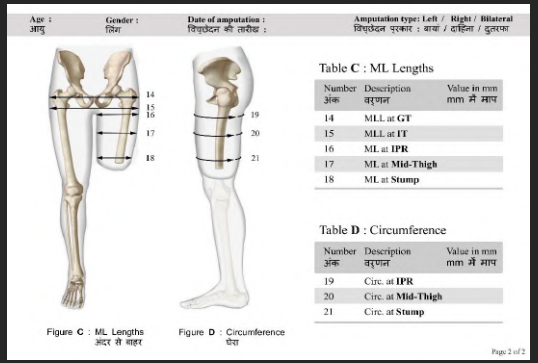

Age :
आयु

Gender :
लिंग

Date of amputation :
विच्छेदन की तारीख :

Amputation type: Left / Right / Bilateral
विच्छेदन प्रकार : बायां / दाहिना / दुतरफा

Figure C : ML Lengths
अंदर से बाहर

Figure D : Circumference
घेरा

Table C : ML Lengths

Number अंक	Description वर्णन	Value in mm mm में माप
14	MLL at **GT**	
15	MLL at **IT**	
16	ML at **IPR**	
17	ML at **Mid-Thigh**	
18	ML at **Stump**	

Table D : Circumference

Number अंक	Description वर्णन	Value in mm mm में माप
19	Circ. at **IPR**	
20	Circ. at **Mid-Thigh**	
21	Circ. at **Stump**	

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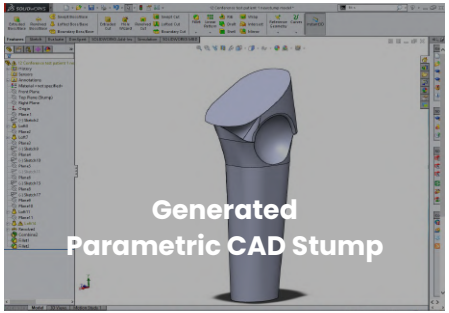
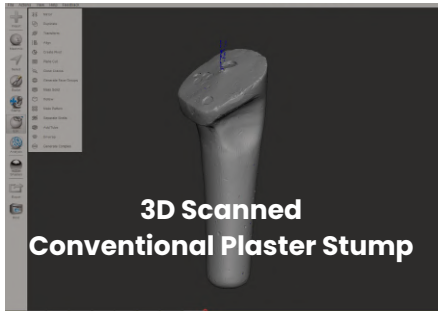
Parametric Stump Modelling

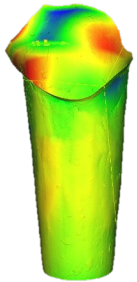
Using field data from measurement camps, we generated parametric CAD stumps of multiple patients, followed by fixing and modifying the form to improve conformity.

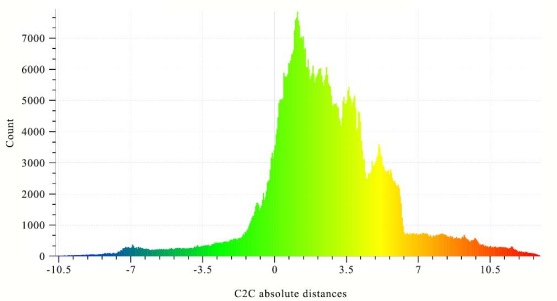
To test the conformity, the parametric CAD stumps were compared to conventional plaster stumps by 3D scanning the plaster stumps using *Steinbichler Comet L3D*.

The distance between cloud points of these two meshes was analysed using *CloudCompare* and were found to have an accuracy of 90% up to 8 mm in deviation.





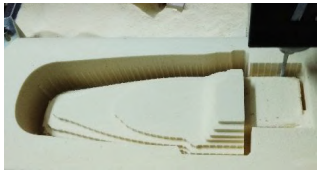




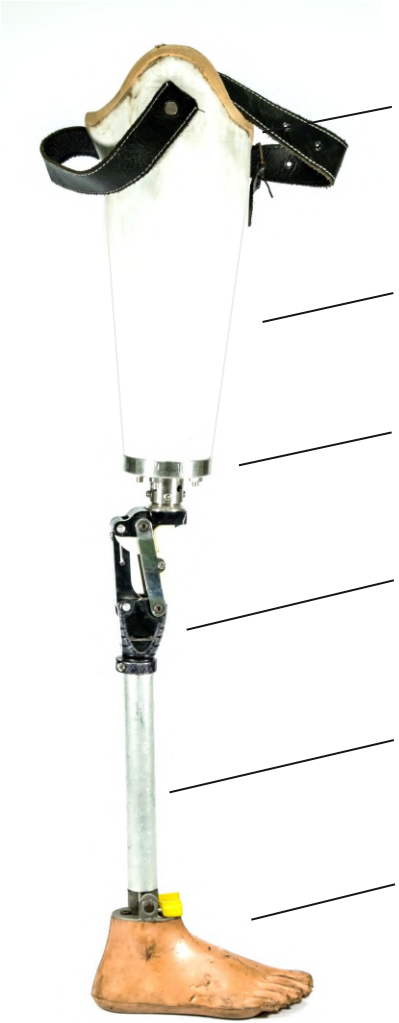
Socket Manufacturing

The parametric model of the patient stumps were exported for manufacturing using CNC machining.

The stumps were then coated before fabricating corresponding sockets using conventional socket molding procedure, followed by the rest of the prosthesis.



The gait of different prostheses was tested at Center for Human Movement Science, MGM Hospital, Mumbai



Belt & Lining
Inner surface is lined with fabric and a belt is provided

Socket
Hand molded using heated HDPE pipe on CNC machined stump

Adapter
Machined in stainless-steel, connects the socket to the knee joint

Knee Joint
Polycentric knee provided by IIT Madras (R2D2 Lab)

Shank
Made from a hollow aluminium tube; length is cut to be customised

Foot
Conventional Jaipur foot, made of polyurethane

Proposed Method

Patients in remote areas do not need to travel to cities since field workers can take their stump measurements and send them to the fabrication centre. The prostheses can be fabricated and delivered to the patients.

The patient-friendly approach leverages design and technology to improve the overall functionality, productivity and affordability, enabling scale-up.