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Prosthetic Fittings Limitations and Its Present Scenario in India and Abroad

M K Mathur

Dr. Mahendra Kishore Mathur currently working as Chief Consultant Research Development & Training, Bhagwan Mahaveer Viklang Sahayata Samiti (BMVSS), Jaipur. After finishing his MS (Orthopaedics) from S.M.S Medical College Jaipur under guidence of Dr. P.K. Shethy on 1983 he worked as a teacher of PMR in same institute for two decades. He has several National and International level of publications. He also contributed chapters in Manuals of Fabrication of Jaipur Below Knee Systems, Fabrication of Jaipur Above Knee Systems, Fabrication of Jaipur Foot, "Jaipur Artificial Limbs" - First comprehensive Text Book on Jaipur Limb Technology.
He is the first orator of Bengal oration of IAPMR on 2012 introduced by West Bengal Chapter of IAPMR.

There is no perfect prosthetic fitting available today in the world. What makes prosthetic systems so interesting is the myriad widely divergent approaches designers are now experimenting – hydraulic, mechanical and computerised.

LOWER LIMB PROSTHETICS

For above knee amputees the prosthetic knee system is among the most complex of all components in prosthesis. This is because knee must give support when people stand, allow smooth motion when people walk and permit movements when people sit bend or kneel. Even in normal gait cycle the knee has to be in full extension at the time of heel strike, goes into flexion just prior to foot flat and toe off and goes through different angles of flexion and extension in swing phase.

Different types of prosthetic knee :

Prosthetic knees range from single axis knee to computerised intelligent knee systems. They can be considered in following groups :

1. Single axis knee joint
2. Polycentric knee joint
3. Hydraulic and Pneumatic knee joint
4. Micro-processor knee joint

Correspondence :
K-23, Malviya Marg,C- Scheme, Jaipur–302 001
Phone Numbers :0141-2366111, 98290-63739
E-mail ID:drmk1@yahoo.com

Every type of joint has some merits and demerits (mentioned below)

1. Single axis knee joint :

Advantages–

- Durable
- Light weight
- Costs less than other knee systems

Disadvantages –

- It has no stance control which means that the amputee must use their own muscle to remain stable while standing.
- Often uses a manual lock to compensate for lack of stance control. This will lead to very poor gait and increase energy consumption.
- Often uses friction system to keep from swinging forward too quickly when moving to next step. This again increases energy consumption.
- It allows for walking with one speed only

2. Polycentric knee joint :

Human knee is polycentric during normal knee flexion and extension, the knee axis moves about a changing centre of rotation (centrode)

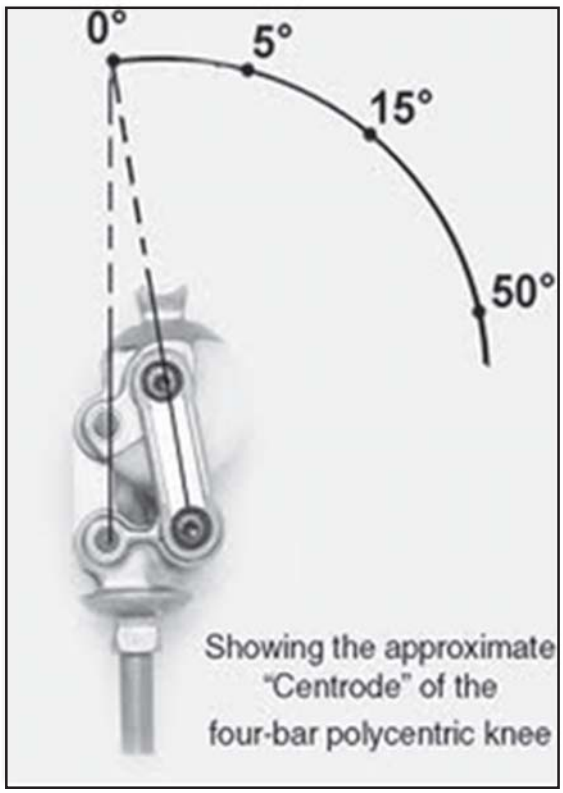
Advantages –

- More natural gait.
- Very stable during early stance.

- Can be provided with weight activated knee brake system which will prevent stumbling and falling of amputee in entire stance ways.
- Reduces the leg length in the beginning of the step again lowering the risk of stumbling.
- Has a simple swing control that allows for an ideal knee control.

Disadvantages –

- May need to be repaired or replaced more often



then other type of prosthetic knees.

- May restrict some knee motion but not enough to be a problem.
- Will have to be provided with a fluid or pneumatic control system to allow variable speed walking.

Polycentric knee joints

Here a new knee joint needs special mention. This polycentric knee has been developed by joint research of Bhagman Mahaveer Viklang Sahayata Samiti (BMVSS), Jaipur with Stanford University – USA. This joint has been appreciated so much by the prosthetic world that TIME Magazine in its issue of 23rd Nov 2009 hailed it as one of the 50-Best Inventions of the world in the year 2009.

Polycentric Knee Joint TIME Magazine Issue 2009

3. Hydraulic and Pneumatic knee joint:

Advantages -

- Provide very natural gait.
- Both extension and flexion are independently adjustable.
- Good stance control to prevent the leg from the buckling out from under the amputee.
- The unit can be temporarily disabled, so that the leg swings freely.

Disadvantages –

- Needs frequent adjustments.
- Frequent replacement of moving parts.

Hydraulic and Pneumatic Knee Joints

4. Microprocessor (Electronic) knee joint :

These are very functional, but the most expensive type, and the maintenance cost is very high. They may be single axis, polycentric, hydraulic and pneumatic etc.

Advantages -

- Usually smaller and lighter weight than mechanical knees.
- Initially programmed to learn user walking characteristic.
- It has timing force and swing sensors that take reading 50 times and instantly control the fluid control system accordingly. Two strain gauge measure pressure on the leg and notes how often the heel strikes.
- It takes fewer efforts to control timing providing amputee with a more natural gait longer walking endurance and better control on uneven surface even while going down the stairs.

Disadvantages –

- Very costly.
- High maintenance and frequent charging is required

Electronic knee joints

Different types of prosthetic foot :

Summaries of the qualities of different knee systems

Generic class	Basic function	Primary indications	Major advantages	Chief limitations
Single axis	Simplicity	Single speed walking	Inexpensive and durable	Fixed cadence and low stability
Stance control	Increase weight bearing stability	General debility, poor hip control	Improved knee stability	Delayed swing phase
Manual lock	Knee of last resort	Ultimate knee stability knee	Eliminate flexion	Abnormal gait awkward sitting
Polycentric	Positive stability and ease of fixion in swing phase	To enhance knee stability	Stable without distrupting swing phase	Increase weight maintenance
Fluid control	Permit cadence change	Able to vary walking speed	Variable cadence	Increase weight maintenance

This can be considered in following groups –

1. SACH foot (solid ankle cushioned heel)
2. Single axis foot
3. Multi-axial foot
4. Dynamic response/ Energy storing foot

1. SACH foot

Advantage -

- Several heel heights, weight categories, manufacturers
- Syme's option
- Durable- low maintenance
- Good choice for padiatrics
- Easy to replace
- Endo or Exoskeleton

Disadvantage –

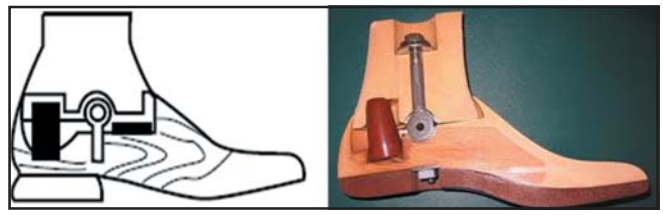
- Useful for amputees with low activity level only.
- Not for use if active keel is needed.
- Poor multi-axial abilities.
- Poor choice if knee stability is questionable.
- Poor shock attenuation.

2. Single axis foot

Two bumpers limit and control ankle dorsi- and plantar flexion. The PF bumper permits the foot to contact the floor more rapidly during loading response than the SACH foot. The more rapid "foot flat" allows the ground reaction force line to move anteriorly, so that it falls in front of the knee and promotes early knee extension and stance stability

Advantage -

- Adjusts joint angle to accommodate uneven terrain (sagittal only).
- Plantar and dorsiflexion bumpers are replaceable with more or less compliant bumpers.
- Relatively inexpensive.



- Indicated when knee stability is an issue.

Disadvantage -

- Increased maintenance associated with moving parts.
- Difficulty cosmetically finishing due to moving parts.
- Contraindicated if knee is stable.
- Contraindicated if multi-axial function is needed.
- Contraindicated if dynamic response is needed.

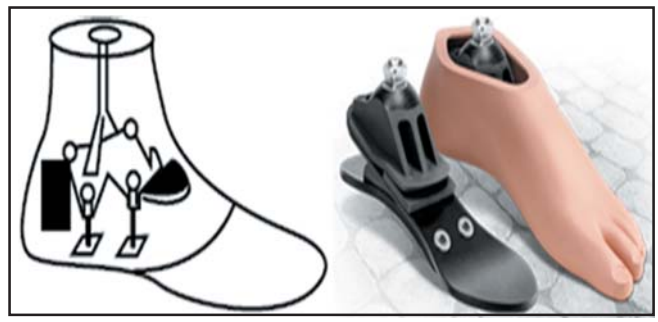
3.Multiaxis foot:

Advantage -

- Because the multiaxial foot permits movement in three planes, it accommodates uneven terrain and absorbs torques which would otherwise produce shearing forces on the residual limb.

Disadvantage -

- Its moving parts are heavy and require maintenance.
- Offers little energy for toe off.
- Increased maintenance, accommodation period and training.



4.Dynamic response/Energy storing foot:

Advantage -

- Returns stored energy, which aids in propelling foot forward at toe off.
- For active ambulators.
- Choice of foot designs is available.

Disadvantage –

- Typically expensive except Jaipur foot.
- Varied cosmetic finishing procedures.
- Moving parts may mean increased maintenance except Jaipur Foot.
- Accommodation period.

Recent Develpment of prosthetic foot :

a) iWalk ankle

Advantages –

They replace the action of foot Achilles tendon and calf muscles to provide a near normal gait to amputee. These foot pieces use combination of processors, sensors, motors and springs which provide the user with a powered push-off and increase range of motion and excellent adaptation to uneven terrain.

Disadvantages –

- Very high cost.
- High maintenance.

b) Bionic foot

Advantage –

- Powered ankle motion.
- Intelligent terrain adaptation.
- Natural function.

Disadvantage –

- High maintenance.
- Very costly.
- Needs frequent recharging.

It can be considered under five categories –

1 Cosmetic prosthesis.
2 Body powered prosthesis (cable controlled).
3 Electrically powered prosthesis (Myoelectric, switch control prosthesis).
4 Hybrid prosthesis.
5 Bionics prosthesis.

1. Cosmetic Prosthesis :

Where the priority is on the restoration of appearance, the design emphasis is on creating a simple, lightweight prosthesis. However, primarily cosmetic solutions are not completely without function:

- The limb may provide passive or opposing functions, such as stabilizing a sheet of paper when writing.
- There is psychological benefit to those patients who are either self-conscious or who face societal pressures.
- There are postural benefits provided by the restoration of body symmetry, these add to the overall

cosmetic benefit and may play a role in preventing associated muscular or skeletal problems emerging over time.

- For very young amputees, bilateral development and increases the likelihood of a successful outcome with functional prostheses in later life.

2. Body powered prosthesis (cable controlled):

Body powered devices are operated using cable and harness systems that require patient to use body movements (moving shoulder or arms) to pull the cable and make the terminal device (a hand, hook or prehensor) open or close much in way a bicycle hand brake system works.

Advantages-

- Lower initial cost.
- Lighter,easier to repair.
- Offer better tension feedback to the body.

Disadvantage –

- Mechanical appearance.
- Difficult to use for some people because they depend on user physical ability.

3. Electrically powered prosthesis (Myoelectric and switch control prosthesis) :

Muscles that are intact after the amputation surgery are used to control limb function. Surface electrodes are carefully position within the prosthesis structure in such a way that when the limb is worn these electrodes lie on the respective muscle bellies and can detect electrical activity within them. The electrodes amplify, filter and process the electrical signals – which arethan passed on to micro-processor within the prosthesis where they act as switching singles to deliver power from to batteries to functional device.

Advantages –

- Do not require a harness or cable and can therefore be built to look more like a real arm.
- Battery powered, so body strength and body movements are not as important for their operation.
- Providing strong grip.

Disadvantages –

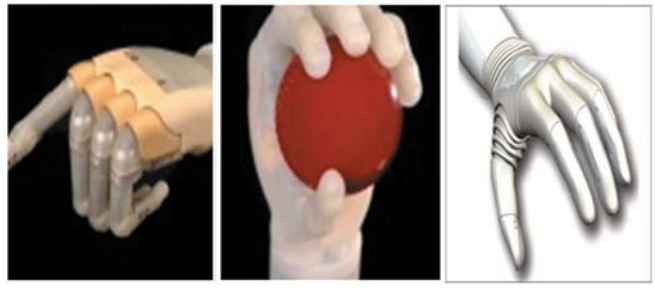
- Higher initial cost.
- Heavier.
- High repair cost.
- Dependents on battery life.

4. Hybrid prosthesis:

In these prosthetic systems some functions are controlled myo-electrically and some functions mechanically. For example hand functions may control myo-electrically, elbow flexion mechanically and elbow locking by an electrical pull switch. There are so many permutations and combinations available in such designs

5. Bionics Prosthesis:

Advancement in microprocessors used in myo-electric systems has allowed artificial limbs too many gains in fine tune control of prosthesis, the iLimb hand. It has four independent motorised fingers and motorised thumb, which is manually rotatable all operating from myo-electrically detected nerve ending in the stump. This hand opens a range of grip and fine motor abilities that prosthetic hands have never had before, like using a key in lock, or one finger typing on a key board. Another important advance is simple yet very effective feedback sensors in the fingers which controls grip pressure to hold fragile items like styrofoam.



WHO World Bank Report 2011

According to WHO World Bank Report 2011 on disability less than 15% of disabled persons could obtain aids and appliances. In India there are more than 70 lac amputees and to this figure about 30,000 new amputees are added every year. By a rough estimate less than 45,000 artificial limbs are fitted in India every year. If we keep on fitting artificial limbs at this rate it may take

several decades before artificial limbs can be provided to all disabled persons in India.

World Design Impact Award

Recently, the world society of designers have selected seven designs from all over world which have improved or likely to improve quality of life of world population. This is called “World Design Impact Award”, you will be happy to know that one of the finalists from out of seven designs chosen from all over world is Polycentric knee joint developed by BMVSS of Jaipur.

Medical Philately

The African Nations are so indebted to Jaipur limb Technology that Kenya Government issued a stamp in their country with an amputee fitted with Jaipur foot.