

Different approaches and cultural considerations in third world prosthetics

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Abstract

The major objective of prosthetics the world over is the same, i.e. to restore the amputee to as functional a capacity as possible in his cultural environment, whilst attaining as good a cosmetic result as can be achieved. At first glance it would seem that this would mean there would be very little difference in approach to the subject in western and in third world countries. Availability of materials, resources and skilled personnel, together with a variety of cultural differences, however, make third world prosthetics a subject in itself.

This paper reviews the literature available on the subject, examines some different approaches to prosthetics in the third world, gives an overview of some materials and designs used and considers adaptations for cultural differences. It concludes that, whilst direct transfer of western prosthetics technology is useful in the short term, for long term benefit to the poorer amputees in the third world, culture-specific designs and materials are more appropriate.

Introduction

A survey has shown that the number of amputees in India in 1981 was approximately half a million (Mohan, 1986); by 1986, although the number of prostheses provided was rising rapidly, the supply was falling further and further behind demand. It was estimated that the number of amputees with no prosthesis was increasing by 17,000 annually. Given that resources for medical care are severely limited in poorer countries and are therefore often used mainly for primary health care affecting a

greater proportion of the population, it would not be surprising if similar figures were reflected elsewhere. The need for prosthetics in the third world is clearly immense.

Golding (1967) has observed that better peripheral circulation, tolerance of minor discomfort and almost total lack of phantom pain actually make the prosthetist's job in the tropics easier in some respects.

The overriding problem in most third world countries is lack of funds, although even where funds are available, direct transfer of western prosthetics techniques is not always successful (Sethi *et al.*, 1978) as cultural differences are not taken into account. There are many aspects to the development of prosthetic services appropriate in these countries, and this paper only touches on some of them.

Approaches to third world prosthetics

In response to the need for prosthetics, many projects have been initiated both from the industrial world and indigenously. Peizer (1977) divides the former into three categories: research aid, where equipment, finance and facilities are provided for research in the developing country; the introduction of a technique or component into an established prosthetics facility; and long range plans with repeated visits to the host country by a team who teach and set up a facility there. He is a strong advocate of co-operation and co-ordination between different projects seeking to bring "modern rehabilitation treatment" to the third world.

The range of activities initiated from the industrial world is, however, much wider than this. For example, relief teams sent regularly for a few days to Haiti (Frederick, 1992) by the "Adopt a Village" campaign in Florida take impressions and measurements which are used

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to fabricate prostheses in the USA. Mobile army units are used in rural Thailand and computer aided techniques in Vietnam (Keokarn *et al.*, 1992). Representatives from some western agencies stay in the host country for a number of years in order to train local people to a sufficiently high standard to continue to run the facility after their departure (Staros, 1992; Heim, 1979; Fago, 1992). Indeed, Staros (1992) attributes the success of their project to a high level of training and a well planned handover. Heim (1992), on the other hand, found that a five year follow-up of a project in Tunisia revealed little advance in procedures after the expatriates left, and recommends periodic follow-up.

Indigenous projects are also wide-ranging in their scope and clientele, with the urban wealthy receiving a very different service from the rural poor e.g. in Latin America (Jensen, 1979). This has resulted in a debate as to the most appropriate way forward for third world prosthetics. The decision makers in many countries are the influential urban professionals, whereas the majority of the amputees are poorer people, often with little education, and with very little voice in the debate (Sethi, 1989). High technology prostheses made in urban centres have, according to Sethi (1989), "symbolic value as opposed to use value"; they are inevitably too expensive for the majority of amputees.

It has also been reported (Sharma, 1991) that many prostheses and orthoses are not worn because they are considered inappropriate, and that the amputees themselves are the best judges of what is functional. Even when attempts are made to ensure that they allow for cultural requirements, like squatting and sitting cross-legged (Chaudhry *et al.*, 1982), they can be so complex that they require considerable maintenance and are totally unsuited to patients who live any distance from a prosthetics facility. Even within one country there can be those struggling to use indigenous materials such as bamboo (Banerji and Banerji, 1984), while others are making highly technical above knee prostheses with linkages, springs and automatic turntables (Chaudhry *et al.*, 1982).

It is widely held, however, that a high priority should be to develop prostheses which are cost effective, durable, easily maintained by local craftsmen, simple in design and suitable for

local climatic, cultural and occupational needs (e.g. Doshi *et al.*, 1992; Girling and Commings, 1972; Gleeson and Marosszeky, 1992; Sethi, 1989; and Vossberg, 1988).

Materials used

According to Wilson (1957), the design of simplified limbs for the third world has been a consideration since at least 1954. Little has been found in the literature on materials and designs used for the upper limb, with the exception of a report on body powered limbs in India. Here different task-specific terminal devices are offered, but hooks are preferred by the few patients for whom cosmesis is not the primary function (Narang *et al.*, 1986). This section, therefore, deals with lower limb components and materials used.

Sockets and shin sections

Polyester resin is commonly used with some success in third world countries e.g. in India (Girling and Commings, 1972; Wollstein, 1972) and Nepal (Meanley, 1991; Vossberg, 1985), but its availability (Meanley, 1991) and reduced shelf life at tropical temperatures (Golding, 1967) make it far from ideal. Traditional material for sockets and exoskeletal limbs or endoskeletal pylons are aluminium (Sethi, 1989), wood (Angarami and Samaria, 1989; Mustapha, 1966), leather and metal (Angarami and Samaria, 1989), and bamboo/cane (Banerji and Banerji, 1984; Kijkusol, 1986). As an alternative for laminating, old X-ray film, acetone gum and stockinette have been used in Indonesia (Golding, 1967), and waste plastic bottles dissolved in thinner are used with gauze bandage in Thailand (Girling, 1972). Thermoplastics have also increased in popularity in recent years, as they have become more widely available (Fago, 1992; Meanley, 1991; Oberg, 1991) and have been used for both sockets and shin sections. Indeed, Oberg (1991) reports that in centres known to him in 14 countries in Africa, South America and Asia, thermoplastics are used alongside more conventional polyester resin and wood. In Argentina, permanently adjustable endoskeletal prostheses have been made using steel and weighing less than 1.8 kg (Angarami and Samaria, 1989).

For soft liners, microcellular rubber and soft leather have been used in Jamaica, India and

Nepal (Golding, 1967; Meanley, 1991), although in Jamaica, there have been problems with the rubber perishing.

Knee joints

Again, India uses a wide range of materials and displays different degrees of complexity. Banerji and Banerji (1984) report the use of coconut shell, but little detail is given. The opposite end of the spectrum is the knee described by Chaudhry (1982), which incorporates a lever system linking knee flexion with ankle dorsiflexion to enable the amputee to squat smoothly. It also uses an automatically operated turntable to allow for descent into a cross-legged sitting position. The middle path is taken by Girling (1972), who describes a constant friction knee joint made from the axis of the front wheel of a bicycle. Although a factory in the north of the country makes components for prostheses, including knees, it is reported that there are no stance phase control joints available in India (Mensch, 1986).

In Argentina, a low cost single axis knee has been developed using a bronze band bearing on the bolt which forms the axis of the knee. It also has an adjustable extension assist on the anterior of the prosthesis (Angarami and Samaria, 1989).

Feet

SACH feet appear to be by far the most popular model in the third world. They are easy to make from local materials (Girling and Commings, 1972; Golding, 1967; Kijkusol, 1986; Meanley, 1991; Mensch, 1986; Pe, 1988) and require little maintenance. Different styles of SACH foot have been made from wood and microcellular rubber. These include designs with a toe-break; a wooden keel and a rubber heel and toe (Kijkusol, 1986); and a solid wooden forefoot with a hyperextended toe section. In some cases the foot is fabricated as part of the laminated shin piece (Wollstein, 1972). This technique is also used for a design modelled on a foot with a forefoot amputation. The advantage of the technique is that the limb can withstand immersion in water or mud repeatedly without damage. Fifteen years of follow-up have suggested that the "forefoot amputation foot" is satisfactory (Kijkusol, 1986). Peg-legs are sometimes used, but are often found to be unacceptable to the patients

(Golding, 1967; Heim, 1979). A wooden rocker foot with a tyre sole has been used in rural Thailand (Jivacate and Tippaya, 1992).

The most remarkable innovation in this area, however, is the Jaipur foot (Sethi *et al.*, 1978; Sethi, 1989 and 1991). This is a cosmetically acceptable foot for use by barefoot walkers. It is made using laminated microcellular rubber forefoot, hindfoot and toe pieces, and a laminated wooden ankle piece with an attachment bolt. The structure is reinforced with cord rubber, encased in coloured rubber cushion compound on the dorsum and rubber tread compound on the sole, and can be vulcanised in a hospital autoclave or large pressure cooker. The use of this style of foot is spreading throughout the Indian subcontinent and further afield. Work is, however, still continuing to produce a lighter weight foot (Moll, 1991).

A more bizarre version of this has been described by other workers in Jaipur (Kabra and Narayanan, 1991). In this foot, the laminated microcellular rubber sections are replaced by preserved, defatted and dried cadaveric bone, complete with ligaments and capsules. The authors claim that in laboratory tests the foot compares with western designs of dynamic feet, but is considerably cheaper. The lack of available cadaveric feet was noted, and the authors suggested that it might be possible to use the amputated foot of the patient, this having a psychological advantage "since a part of the anatomy hitherto considered irretrievable is being used for his or her rehabilitation".

Cultural considerations and adaptations

Many centres are seeking to ensure that the limbs they produce are appropriate to the culture in which they are situated. Although some of these specific requirements are being met, a lot more work is required to fulfil the goal of prosthetics to return the amputee to as functional a capacity as possible within his environment. A few of these considerations and adaptations are described below.

In many countries in tropical areas, barefoot walking or the use of open toed sandals is common, or footwear is removed when entering a home or place of worship. Cosmesis is clearly important in these areas, as well as durability of the foot. The Jaipur foot seeks to address this problem. Indeed, in response to requests by amputees wishing to wear and remove shoes, a

Jaipur foot with removable heel has been made to allow for the heel height of the foot (Sethi, 1989). This foot also allows for squatting, absorbs torque sufficiently for cross-legged sitting of trans-tibial amputees and has enough inversion/eversion to facilitate walking on uneven ground, all of these activities being carried out several times daily in many countries. Due to its dorsiflexion capacities and the grip of the sole rubber, climbing trees is also possible for some amputees (Sethi *et al.*, 1978; Sethi 1989 and 1991); this can be an essential activity for picking fruit or collecting leaves or branches for animal fodder. The spring loaded turntable is an attempt to allow for cross-legged sitting and squatting of trans-femoral amputees (Chaudhry *et al.*, 1982).

In some countries it is customary for younger people to genuflect or kneel before elders, and failure to do this is considered an insult; the use of a knee joint in these circumstances become very important (Oshin, 1981). In addition, simple, durable designs are vital for rural communities where patients may live several days' walk from the prosthetics centre, and cannot afford time away from the fields to attend a clinic for repairs; local craftsmen may find themselves doubling as prosthetics technicians in this situation. The use of plastics or other materials which will neither rust nor rot is important in communities where much walking is done through mud, and wading through rivers is a daily occurrence (Sethi, 1989; Meanley, 1991).

Clearly, when cultural requirements such as squatting, sitting cross-legged, tree climbing and kneeling are considered, it can be seen that western prosthesis designs will not be appropriate in such settings. Local conditions such as uneven terrain, the need to walk through rivers and mud, the presence of pests which eat wood, rubber etc., will also have an effect on the design and materials used.

Finally, "preventative prosthetics" might be an appropriate line to take in some areas. For instance, in Cambodia, which has the highest number of amputees per capita in the world, the main cause is explosion of land mines left over from the war. The majority of casualties are civilians. Detection and destruction of the remaining mines, though a difficult task, would clearly reduce the number of amputees. In India, most upper limb amputations are the

result of a poor understanding of the use of new farming machines (Narang *et al.*, 1986; Vohdra, 1992); training in their use and the importance of safety procedures would be beneficial here.

Conclusion

The need for prosthetic services in third world countries is immense and although much is being done to address this problem, there is sometimes a lack of co-ordination (Peizer, 1977). There is the "relief" approach, which seeks to meet some of the immediate need, and has its successes, and there is the "development" approach, which looks to work for more lasting solutions, these being both indigenous and western initiated. Although this paper emphasises the "development" angle, "relief" work is also acknowledged to be valuable in improving the functional capacity of many people.

The direct transfer of western prosthesis design to the third world is not considered to be appropriate in the long term for two main reasons. Materials and equipment can be prohibitively expensive in many countries, so that their use can lead to aid dependency rather than independence. Secondly, local conditions and customs are not taken into account in their designs so they can be inappropriate in many settings.

There is much to be done to improve both designs and availability of prostheses in the third world, but perhaps the words of Sethi (1991), the designer of the Jaipur Foot, will prove to be the key to his and others' success in this area: "Need for alterations kept on arising and were ready to respond to them".

Acknowledgements

This work was carried out at Northwestern University Prosthetic Orthotic Center in part fulfilment of its Certificate Course, 1992.

REFERENCES

- ANGARAMI GR, SAMARIA CE (1989). An efficient low cost prosthetic structural system. *J Prosthet Orthot* 1, 86-91.
- BANERJI B, BANERJI JB (1984). A preliminary report on the use of cane and bamboo as basic construction materials for orthotic and prosthetic appliances. *Prosthet Orthot Int* 8, 91-96.
- CHAUDHRY KK, GUHA SK, VERMA SK (1982). An improved above-knee prosthesis with functional versatility. *Prosthet Orthot Int* 6, 157-160.

- DOSHI MM, DESHPANDE SA, RAMDAS G (1992). Management of four limbs amputee - technology for developing countries. In: Proceedings of Seventh World Congress, International Society for Prosthetics and Orthotics, Chicago, June 28-July 3, 1992.- Alexandria, VA: ISPO. p249.
- FAGO J (1992). Tutor with Handicap International. Personal Communication.
- FREDERICK J (1992). Founder of "Adopt a Village". Personal Communication.
- GIRLING J, COMMINGS G (1972). Artificial-limb fabrication without the use of commercially available components. *Prosthet Orthot Int* 4, 21-25.
- GLEESON RC, MAROSSZEKY JÉ (1992). Rehabilitation issues in the management of a New Caledonian adolescent with multiple limb amputations. In : Proceedings of Seventh World Congress, International Society for Prosthetics and Orthotics, Chicago, June 28-July 3, 1992.- Alexandria, VA: ISPO. p248.
- GOLDING JSR (1967). Prosthetics in countries with low per capita income. *Prosthet Orthot Int* 3, 26-30.
- HEIM S (1979). The establishment of prosthetic services in African countries. *Prosthet Orthot Int* 3, 152-154.
- JENSEN E (1979). Prosthetics and orthotics in Latin America. *Prosthet Orthot Int* 3, 155-156.
- JIVACETE T, TIPPAYA B (1992). Prostheses from waste plastic bottles. In: Proceedings of Seventh World Congress, International Society for Prosthetics and Orthotics, Chicago, June 28-July 3, 1992.- Alexandria, VA: ISPO. p250.
- KABRA SG, NARAJANAN R (1991). Ankle-foot prosthesis with articulated human bone endoskeleton: force-deflection and fatigue study. *J Rehabil Res Dev* 28(3), 13-22.
- KEOKARN T, KUNATHAI C, KUKIETNAN S, JONGFUENPRINYA F (1992). The role of the army mobile prosthetic-orthotic team in North East Thailand. In: Proceedings of Seventh World Congress, International Society for Prosthetics and Orthotics, Chicago, June 28-July 3, 1992.- Alexandria, VA: ISPO. p246.
- KUKUSOL D (1986). Simplified low cost below-knee prosthesis. *Prosthet Orthot Int* 10, 96-98.
- MEANLEY S (1991). The development of a prototype patella tendon bearing prosthesis using high density polyethylene piping (the drainpipe leg). *J Med Eng* 205H, 121-123.
- MENSCH G (1986). Aids and equipment: prosthetic update. *Physiotherapy Canada* 38, 369-371.
- MOHAN D (1986). A report on amputees in India. *Orthot Prosthet* 40(1), 16-32.
- MOLL K (1991). Prosthetist/Orthotist with ADD Mobility, India. Personal Communication.
- MUSTAPHA AH (1966). The role of prosthetic and orthotic rehabilitation in Sierra Leone. *Orthop Prosthet Appl J* 20, 237-239.
- NARANG IC, MATHUR BP, SINGH P, JAPE VS (1986). Clinical survey of upper extremity amputees in India. *Orthot Prosthet* 40(2), 29-37.
- OBERG K (1991). Cost-benefits in orthopaedic technology by using thermoplastics in developing countries. *Prosthet Orthot Int* 15, 18-22.
- OSHIN TA (1981). Indigenous substitutes for modern prostheses and orthoses. *Prosthet Orthot Int* 5, 144-146.
- PE H (1988). A fifteen year survey of Burmese amputees. *Prosthet Orthot Int* 12, 65-72.
- PEITZER E (1977). Planning prosthetic and orthotic programmes to aid developing countries. *Prosthet Orthot Int* 1, 119-124.
- SHARMA VP (1991). The care of the limb deficient child in India. *Prosthet Orthot Int* 15, 143-145.
- STAROS A (1992). Establishment of a prosthetics and orthotics center in Tegucigalpa, Honduras. In: Proceedings of Seventh World Congress, International Society for Prosthetics and Orthotics, Chicago, June 28-July 3, 1992.- Alexandria, VA: ISPO. p252.
- SETHI PK, UDAWAT MP, KASLIWAL SC, CHANDRA R (1978). Vulcanised rubber foot for lower limb amputees. *Prosthet Orthot Int* 2, 125-136.
- SETHI PK (1989). Technological choices in prosthetics and orthotics for developing countries. *Prosthet Orthot Int* 13, 117-124.
- SETHI PK (1991). Jaipur foot revisited. In: Recent advances in surgery. Volume 14, edited by I Taylor, CP Johnson.- Edinburgh: Churchill Livingstone p307-321.
- VOHDRA DS (1992). Rehabilitation of arm amputees in developing countries - India. In: Proceedings of Seventh World Congress, International Society for Prosthetics and Orthotics, Chicago, June 28-July 3, 1992.- Alexandria, VA: ISPO. p247.
- VOSSBERG A (1985). The development of orthopaedic appliances and low cost aids in "least developed countries". *Prosthet Orthot Int* 9, 83-86.
- VOSSBERG A (1988). The choice of prosthetic and orthotic technique for less developed countries: analysis and perspectives in Colombia. *Prosthet Orthot Int* 12, 96-100.
- WILSON DV (1957). Prosthetics: a worldwide interest - a summary of the program of the International Society for the Welfare of Cripples and International Activities in the Field of Prosthetics. *Orthop Prosthet Appl J* 11, 57-63.
- WOLLSTEIN LV (1972). Fabrication of a below-knee prosthesis especially suitable for tropical countries. *Prosthet Orthot Int* 4, 5-8.