

THE KNUD JANSEN LECTURE

**Culture-sensitive innovations for quality living  
of lower limb amputees**

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**Introduction**

I am very grateful to the President and the Executive Board of ISPO for this opportunity to address the distinguished Knud Jansen Lecture at the 11th World Congress.

I first met Dr. Knud Jansen, founder of the ISPO, in 1968, at the Orthopedic Hospital, Copenhagen. Dr. Jansen told me that there was little information about the prosthetic field in Japan, and asked me to be his point of contact with Japan in future. He also wanted Japan to play its part for prosthetic and orthotic development in Asia. This led to the foundation of the Japan National Member Society of ISPO, and I have been involved in many ISPO activities since then, including serving as President of ISPO (1995-98) and as Secretary General at the 6th ISPO World Congress in Kobe in 1989. Over the years I have been happy to organize a number of seminars and conferences around Asia in the course of my work as an international consultant. I believe the most important task for raising the level of prosthetics and orthotics services in low-income countries is to educate prosthetists and orthotists, and that idea has led me to work with Dr. Eiji Tazawa for over ten years towards the establishment of a Category-I university course for low-income countries in Asia. I am glad to say that we have succeeded in opening Colleges of Prosthetics and Orthotics at Mahidol University and Sirindhorn Medical Rehabilitation Center in Thailand, with the

cooperation of the Nippon Foundation. The Colleges opened in 2002 and offer Bachelor degrees. I believe Dr. Jansen would be very happy with this success.

**Culture-sensitive innovations for quality living of lower limb amputees**

***Innovations in lower limb prosthesis, aiming to provide quality living through a team approach***

Lower limb amputees in Japan must solve many problems in the context of a way of life that differs from the West in lifestyle, cultural, religious and other aspects. In line with the main theme of this World Congress, which is "Innovations for Quality Living", I would like to present the difficulties which Japanese lower limb amputees encounter in their activities of daily living, and the solutions which we have been working on by developing prosthetic fitting methods and components.

Of course, improvement of quality of life for amputees requires a comprehensive service for their rehabilitation, including medical, psychosocial, vocational and other aspects, delivered through a teamwork approach. At the Hyogo Rehabilitation Center, we have achieved results in many cases through the participation of specialists well-trained in the amputee rehabilitation field. In particular, innovation in prostheses requires improved socket fitting technology, research and development into new materials, joints and parts, and the development of prosthetic training to take advantage of them. One example is our efforts for the research and development of intelligent prostheses over many years, intended to enable trans-femoral amputees to walk at the same speed as able-bodied people. Commercial development of the

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better results of our research and development work has satisfied many trans-femoral amputees. Physical therapists must receive appropriate prosthetic training to make the most of the properties of intelligent prostheses. The second step in the training by therapists is gait training, which enables subjects to vary their gait speed smoothly from a slower to a more rapid pace. To do that, the therapist applies resistance from in front of and behind the amputee to train the amputee in a prosthetic gait that matches the therapist's stride and cadence. For amputees to function in daily life, it is important that they be able to run in order to cross a crosswalk before the light changes color, or to board a bus or train in time. Appropriate prosthetic for higher activities is also needed if amputees are to enhance their quality of life with sports and recreation.

#### *Prosthetic development focusing on Japanese cultural considerations*

After I chose the rehabilitation of amputees as my life's work, I took my first course as a doctor through the Prosthetic Education Project at UCLA. However, desk learning alone cannot give an adequate understanding of prosthetic fitting and alignment, so I underwent training as a prosthetist. After I studied immediate postsurgical prosthetic fitting under Professor Marian Weiss and Dr. Ernest Burgess, in 1973, I applied immediate fitting techniques to hip disarticulation and trans-pelvic amputation, and gained extensive experience. I came to the conclusion that early prosthetic fitting is a key factor for success with upper limb prostheses, in addition to being necessary for lower limbs. One point I particularly want to emphasize for the sake of achieving superior results is close teamwork between doctors, prosthetists, therapists and other professionals with detailed knowledge of amputee rehabilitation and prosthetic fitting.

After I returned to Japan in 1961, I was asked to participate in a mobile clinic that would work in 35 rural areas per year. That was the beginning of a prescription and supply service which provided 3,000 people with disability with prosthesis, orthosis, wheelchairs and other needs each year. In the course of that work I learned of many amputees who were troubled because prosthetic technology imported from the West was not adapted to Japan's very different

way of life. In particular, the customs of removing shoes at the entrance and sitting on tatami mat floors, and the style of Japanese toilets necessitate a 130° angle of movement at the knee joint. The prosthesis itself must have a rotation mechanism to allow the amputee to sit cross-legged or with legs folded to one side. I believe these Japanese problems also occur in other Buddhist countries such as Thailand, India and Islamic countries, where amputees must be seated on the ground to pray, and their toilets pose similar difficulties.

To tackle these difficulties in daily life, one Japanese trans-femoral amputee began developing a turntable with a rotation function in 1940, the first development of its kind. It was highly praised for making daily life more convenient, most notably for sitting on the floor and removing shoes, and manufacturers put products on the market using the turntable. However, there was some dissatisfaction with the turntable, which was made for exoskeletal prosthesis, because of its heavy weight and its durability. Many types of turntables were subsequently developed when endoskeletal prostheses were introduced. Bilateral trans-femoral amputees, in particular, use the turntable when getting into cars, as well as indoors. When they drive, using hand operation, the turntable is important for facilitating control by allowing space between the steering wheel and the prostheses, and for allowing the stump to relax during driving. Removing shoes at the entrance to a home involves alteration of alignment because the heel height changes. Prosthetic feet have been developed that can be adjusted so that their angle accommodates the change of alignment, and it is particularly useful to bilateral lower limb amputees. If trans-femoral amputees are to assume a formal sitting position (in which the feet are folded back under the body), the knee must have full flexion, and the foot must have a plantar flexion function.

Amputees who work in agriculture in Japan do not always accept modern prostheses that we would think of as ideal. They prefer to use a conventional prosthesis made of aluminum, with a knee lock. There are also numerous cases in which a Dollinger foot assists amputees in their daily lives. I have often seen bilateral trans-femoral amputees employed in agriculture who actually find it more difficult to do their jobs with a conventional long prosthesis. In such

cases, a short prosthesis with a double socket for endbearing is more functional, as well as being easier to fit the socket, which makes it better suited to the Japanese way of life.

*Prosthetic problems and solutions affecting each amputation level within the Japanese way of life*

Next, I will describe the prosthetic problems that lower limb amputees in Japan encounter in their daily lives, depending on the position of their amputation, and the efforts we have made to solve those problems.

*Hip disarticulation prosthesis*

Follow-up of 45 conventional Canadian-type hip disarticulation prosthesis users demonstrated that socket tightness when sitting on the floor indoors was a problem in Japan's warm, humid climate. The solutions are diagonal or open window socket types, or, when requested by the amputee in extreme cases, a half socket secured by two wide belts.

As a rule, a turntable is always prescribed to facilitate sitting on the floor. The turntable makes it easier to assume a cross-legged or sideways sitting position, and to take shoes on and off. The turntable prescription also makes it easier to get into and out of cars, so it would appear to be valuable for use in the West as well. Elderly amputees using hip disarticulation prostheses in rural areas will have more opportunities to go out if they also use crutches or a wheelchair, and if a wheelchair lift is installed to overcome large steps in their houses.

*Trans-femoral prosthesis*

1. Compared to a short trans-femoral amputation, the hip disarticulation prosthesis is undesirable because of the discomfort of the socket, which covers the whole pelvic area. Therefore, we have tried to fit sockets that cover a wide area of the lateral and posterior parts of the stump and achieve suspension by abduction of the remaining femur in swing phase. The main problem affecting socket fitting for short trans-femoral amputations is that the stump can slip out of the socket during the hip flexion that is required to sit down. To prevent that, we mount a separate joint immediately below the socket, which makes it easier for the socket to remain fitted when the user sits

down. That joint, combined with the use of a turntable, also makes it easy to take shoes on and off.

2. When the trans-femoral amputee has an occupation which requires prolonged sitting in the formal position, such as priests, the addition of a rotation function to the lower leg pylon allows the foot to turn inward or outward, so that the position can be assumed.

3. In addition to a knee joint with full flexion, the development of prosthetic feet which have a wide range of angular movement for dorsiflexion and plantar flexion has made it easier to use plantar flexion when sitting in the formal position. The development of prosthetic feet with a wide range of movement that is impossible with normal joints makes it possible for users to work in a squatting position. This position is suitable for people who work close to floor level, such as carpenters and tile layers, and might even give the amputee an advantage over an able-bodied person.

4. Bilateral trans-femoral amputees remove their shoes at the entrance to a home, but change to indoor shoes of the same heel height. This is a measure to avoid the change of alignment caused by the customary removal of shoes indoors. They put on and remove the prostheses at the bedside, and carry on many everyday activities in the home, such as bathing and using the toilet, with their prostheses removed. Detailed prescriptions are required to provide stable knee joints and feet with rigid heels, to allow users to stand safely without support from either hand, such as when dressing or tying a necktie.

*Knee disarticulation prosthesis*

Knee disarticulation allows end-bearing on the stump, which offers many advantages for mobility and performance of tasks in Japanese interiors. The development of a knee joint that provides swing phase control functions for knee disarticulation prostheses has long been a challenge. The Hyogo Rehabilitation Center has been researching and developing a 4-bar linkage knee unit with pneumatic swing control since 1975, and the developed knee can solve the problem, enabling improvements in gait pattern and speed. The problem is that the bulbous shape of the stump end makes it difficult to fit the

socket. Sockets with open windows have been used for fitting until 1980, but there have been known problems of durability and cosmesis for such sockets. In conventional prostheses, a painful load is imposed on the stump when the user sits in a cross-legged position, unless the socket itself has a rotation function, so that users have been practically unable to sit in that position. The solution was to fashion an inner socket, in which the indentation, where the supracondylar area of the stump becomes slimmer, is filled with a circular sponge. The rotation of the socket is facilitated, and plastic lamination is used on the outside of the socket to fabricate the outer socket. There is a slit in the inner socket to make it easier to fit it on. A rotation function between the inner and outer sockets facilitates rotation of the inner socket by moving the outer socket by a few centimeters, so the user can sit cross-legged. The durability of the socket is improved, and this amputation level is now clearly superior to trans-femoral amputation in aspects such as end-bearing, fitting long lever arm of stump.

#### *Trans-tibial prosthesis*

1. In the case of trans-tibial amputation due to trauma or malignant tumour (excluding cases due to vascular disease and diabetes mellitus), it is advised to keep stump length as long as possible. The reason is that a long stump provides more leverage, so the fitting performance can be maintained even when the posterior wall of the socket is made lower. This arrangement eases flexion of the knee joint, making it easier to ride a bicycle.
2. In general, the PTB is prescribed for 70% of trans-tibial amputations in Japan. However, many users in Japan say that a greater degree of knee flexion is required for activity of daily living in Japan. Therefore, detailed consideration must be given to the design and attachment position of the cuff belt shape, the selection of materials with elasticity, and other aspects.

3. Sockets are prescribed with short stumps to keep the socket as high as possible, to achieve stability when walking. The patellar-tendon supracondylar PTS socket is a particularly desirable prescription. For female users, the PTS is a particularly desirable. One characteristic of the PTS socket is that knee flexion can make the stump slip out of the socket. This property makes it easier to assume a formal sitting position.

#### *Syme's amputation prosthesis*

Syme's amputation has the characteristic of allowing end weight bearing on the stump, which is a great advantage for living with Japanese tatami matted rooms and bathing arrangements. Double-wall sockets have been used with Syme's amputation, in the same way as for knee disarticulation, for nearly 40 years. They offer superior durability, and are accepted by even elderly amputees and bilateral lower limb amputees as a superior amputation position.

#### **In conclusion**

I have described the research and development process by which prosthetic fitting techniques from the West have been adapted to the Japanese way of life, to suit the needs and activities of Japanese amputees. I hope this presentation has provided some information of use to Western amputees, so that we can support as many lower limb amputees as possible and assist their participation in society.

The results I have described are certainly not the fruits of my solo efforts. Rather, I must emphasize, they have been made possible by excellent teamwork and research by the members of the Lower Limb Amputee Project at the Hyogo Rehabilitation Center. I am deeply grateful to them for their efforts.