

## **Effectiveness of prosthetic rehabilitation of children with limb deficiencies present at birth**

G. ŞENER, K. YİĞİTER, K. BAYAR and F. ERBAHÇECİ

*Prosthetics and Biomechanics Department, School of Physical Therapy Rehabilitation, Hacettepe University, Ankara, Turkey*

### **Abstract**

This study was performed to investigate the efficacy of prosthetic rehabilitation in children with congenital malformations, also to determine whether there were any factors related to family history and pregnancy which could have affected the formation of such deficiencies.

Twenty-five (25) limb deficient children were provided with prostheses and received rehabilitation. A detailed family and pregnancy history was researched through the records. The ability of performing activities of daily living was scored on a four point scale.

Thirteen (13) lower and 12 upper limb deficient children with a mean age of  $4.88 \pm 2.52$  years were included in the study. Ten (10) children had longitudinal and 15 transverse deficiencies. Traditional marriages amongst close cousins were observed in 31%. Five (5) mothers used medications, 2 received radiodiagnostic tests and 2 had bleedings during pregnancy.

Some 84.7% of the lower limb group became independent walkers without requiring walking aids while 15.3% of them required Canadian crutches for independent ambulation. A total of 61.5% of these children actively participated in recreation with peers. In the upper limb group 41.6% were completely independent in self-care, feeding and hand skills; 33.3% showed independence with self-help devices while 25% tended to use the prostheses for assistive purposes. Participation in recreational activities was 58.2%.

All correspondence to be addressed Prof. G. Şener, Department of Prosthetics and Biomechanics, School of Physical Therapy Rehabilitation, Hacettepe University, Samanpazari, 06100 Ankara, Turkey.

The author's results have shown that the children gained a functional activity level although the prostheses were provided in a late period. It can be concluded that success in rehabilitating these children is a true challenge.

### **Introduction**

Congenital anomalies are classified as being either transverse, in which all the skeletal elements distal to the level of loss are absent as in an acquired amputation, or longitudinal in which some distal skeletal elements remain (Day, 1991; Krebs *et al.*, 1991; Jain, 1996; Esquenazi and Meier, 1996).

The prosthetic rehabilitation of children with congenital limb deficiency differs little from the acquired amputations, especially if the anomaly is transverse. Usually the limb deficient child not need pre-prosthetic care and is considered to be an essentially normal child who happens to have limb deficiency. In the case of longitudinal limb deficiency the prosthetic care may be combined with amputation or surgical reconstruction (Krebs *et al.*, 1991; Rosenfelder, 1980; Czerniecki, 1996).

Appropriate prosthetic treatment, proper rehabilitation, the family attendance and interest in therapy are the key points leading the child to independence. However, it is important to separate the concept of function from that of wearing a prosthesis. Each child is unique and must be evaluated in a detailed perspective by the orthopaedic surgeon, physiotherapist and prosthetist. The anticipated functional benefits or loss must be discussed before the prescription and initiation of the treatment (Krebs *et al.*, 1991; Rosenfelder, 1980; Jain, 1996).

Age of fitting is another important

consideration; when the developmental readiness occurs the child must be provided with a prosthesis (Rosenfelder, 1980). Unilateral lower limb deficient children at any level and those with bilateral loss from below the knees are ready for their prosthetic fitting when they pull to stand between 9 and 12 months. In upper limb deficiencies, fitting should be done when independent sitting is achieved about 6 to 8 months of age (Curran and Hambrey, 1991; Hirons *et al.*, 1991; Krebs *et al.*, 1991; Lovett, 1991; Rosenfelder, 1980; Jain, 1996; Esquenazi and Meier, 1996).

This study was performed to investigate the efficacy of prosthetic rehabilitation in congenital malformations, also to determine whether there were any factors related to family history and pregnancy which could have affected the formation of such deficiencies.

### Patients and methods

Twenty-five (25) unilateral limb deficient children consisting of 15 girls (60%) and 10 boys (40%), with a mean age of  $4.88 \pm 2.52$  years were included in the study. Thirteen (13) children had lower and 12 had upper limb deficiencies.

Limb deficiency was longitudinal in 10 children while 15 had transverse deficiencies. Seven (7) children (54%) had transverse and 6 (46%) had longitudinal deficiencies in the lower limb group while 8 children (67%) had transverse and 4 (33%) had longitudinal deficiencies in the group with upper limb involvement (Table 1).

All the patients were referred by orthopaedic surgeons and 7 children had undergone surgical reconstruction because of bony growths.

In the initial visit, a detailed evaluation was performed including muscle strength and shortening, range of joint motion, the type of deformity, current and expected functional level, activities of daily living and the discussion about the requirements for prosthetic treatment.

Existence of traditional marriages amongst close cousins, other congenital malformations in the family, pregnancy age, inappropriate care including alcohol, cigarettes, any medications, radiodiagnostic tests and bleedings during pregnancy were researched through hospital records.

The design of the prostheses and the selection of materials were carried out considering individual needs depending on the level or type of the deformity. During their rehabilitation period all the patients received unfinished prostheses; alignment adjustments and modifications in the socket were made as required.

Extension prostheses were made for 6 children with Proximal Femoral Focal Deficiency. Trans-femoral prostheses with knee joints and quadrilateral sockets were given to 2 children with transverse deficiencies at above-knee level, while 5 children with loss at below-knee level were fitted with Patellar Tendon Bearing-Suprapatellar-Supracondylar Suspension trans-tibial prostheses using soft sockets. SACH (Solid Ankle Cushion Heel) feet were utilised in all lower limb prostheses (Bochman, 1981).

In the upper limb group, 9 trans-radial prostheses were made for 7 with forearm deficiencies and 2 children with longitudinal ulnar deficiencies, while 1 child with longitudinal deficiency was fitted with a modified elbow disarticulation prosthesis consisting of two sockets with lateral joints for attaining elbow flexion. Shoulder disarticulation prostheses were made for one with a gross longitudinal deficiency and one transverse deficiency at the level of the shoulder.

During the socket fit and the alignment of lower limb prostheses the following criteria were applied:

- child could stand with equal weight on both feet;
- there were no soft tissue rolls over the socket brims;
- child was comfortable and stump/involved limb was free from any pain during standing and sitting;
- skin was in good condition, free from cyanosis, excessive redness after prosthesis was removed;
- top of prosthetic foot and prosthetic joints were parallel to floor when standing;
- suspension of the prosthesis was adequate;

Table 1. Deformity type of the amputees.

Type of deformity	Lower limb		Upper limb		Total	
	N	%	N	%	N	%
Longitudinal	6	46	4	33	10	40
Transverse	7	54	8	67	15	60
Total	13	100	12	100	25	100

- the length of the prosthesis was 1.5cm longer than the sound limb and a shoe rise of the same length was placed under the sole and heel of the shoe of the sound limb for ease in lengthening the prosthesis when necessary due to growth.

Upper limb deficient children were given mechanical prostheses with a voluntary opening terminal device and the following criteria were applied for comfort and function:

- the brims of the sockets were appropriate and not preventing mobility of the related joints;
- the length of the prosthesis was equal to the sound side;
- the mechanism and cables of the control system were modified for ease in terminal device operation;
- harness system was properly designed, not producing excessive pressure under axilla and providing sufficient suspension and functional support;
- the child was comfortable and free of pain during activities;
- the skin was free of excessive colour changes and discomfort when the prosthesis was removed.

Not boring the child was an important factor therefore the duration of prosthetic training sessions naturally varied from child to child.

In the lower limb deficient children training started with free walking in order to give the child a chance for adapting to the prosthesis, and to feel that walking was not a dangerous pursuit. Balancing and weight-shifting activities were assisted by exercise but more emphasis was given to comfort, functional alignment, overcoming insecurity and participation in games with peers rather than the fine points of walking. The prosthetic training continued with activities such as ascending and descending stairs and inclines, walking on uneven terrain, crossing obstacles, picking up objects from the floor, getting on and off a vehicle.

Initial training of the child with upper limb deficiency focused on teaching the child to open the terminal device (prosthetic hand). Since all the prostheses were cable-operated and had voluntary opening terminal devices (TD), an object was placed in the TD by the physiotherapist. The therapist then performed scapular abduction passively by moving the child's arm to open the TD. This was followed by active participation of the child to open the

TD, close it on an object, and release the object. Treatment primarily consisted of games and play activities to stimulate use of the prosthesis. When the child was successful in control motions of TD, training was directed towards the activities of daily living. Self care such as dressing, brushing teeth and hair, feeding activities and hand skills including holding the telephone receiver, pencil and paper, holding and opening jars, catching a ball using two hands, opening and closing doors were experienced by the child. Adequate time was given to the child to perform the activity and assisted only when necessary. Active positioning, locking and unlocking of the elbow joint was taught to the children with shoulder disarticulation prostheses.

At the end of the training period, the children were assessed for their ability to perform activities of daily living on a four point scale.

The child was considered independent when an activity was performed without using any aids or assistance. If the activity was done independently with the aid of a walking or self-help device he/she was considered independent with the help of a device. When the child could perform the activity with the assistance of someone else he/she was partially independent with assistance and dependent for particular activity if he/she could not perform it at all.

## Findings

When the factors related to family history and pregnancy which could have affected the formation of such deficiencies were researched, traditional marriages amongst close cousins were present in 8 (32%) parents. Five (5) mothers (20%) used medications during pregnancy, 2 (8%) received radiodiagnostics tests, 2 (8%) had bleedings during the first trimester of pregnancy. There were no other specific factors in the remainder (32%) (Table 2).

Table 2. Family history and pregnancy care.

	N	%
Traditional marriages	8	32
Medications during pregnancy	5	20
Radiodiagnostic tests during pregnancy	2	8
Bleedings during pregnancy	2	8
No specification	8	32
Total	25	100

The mean pregnancy age was found to be  $27.14 \pm 6.49$ , while the fathers' mean age was  $32.03 \pm 8.61$  at this period.

When the place of the limb deficient child among siblings was observed it was seen that 4 patients (16%) were the first children of the family, 8 of them (32%) were the second children, 7 (28%) were the third children, 3 (12%) were the fourth, 2 (8%) were the fifth children of the family and 1 (4%) was the sixth child of the family.

The average prosthetic rehabilitation period was 18 days. Before prosthetic treatment, all of the lower limb deficient children were ambulating with walking aids. When the 13 children with lower limb malformation were reassessed after rehabilitation, it was seen that 11 of them (84.6%) became independent walkers performing the ambulatory activities without necessitating walking aids while 2 children (15.3%) required Canadian crutches for independent ambulation. Eight (8) of these children (61.5%) actively participated in recreational activities with peers. Five (5) children played football while 3 children were successful in table-tennis.

Before prosthetic treatment, children with upper limb deficiency performed activities of daily living with difficulty either by using their sound limb or by the assistance of the parents. After prosthetic rehabilitation, 5 children (41.6%) became completely independent in self care, feeding and hand skills, 4 children (33.3%) showed independence with self-help devices while 3 children (25%) required assistance from someone else and tended to use the prostheses for assistive purposes. Those were the children with proximal amputations or deficiencies; one with gross longitudinal deficiency, one with shoulder disarticulation and one with ulnar longitudinal deficiency whose elbow joint was ankylosed in extension. Seven (7) children (58.3%) participated in recreational activities. They played games such as constructing different objects from cubes and Lego toys just like their peers.

## Discussion

The results showed that the children gained a functional activity level although the prostheses were provided in a late period. Krebs *et al.* (1991) reported that about 16% of children with congenital amputations do not receive prosthetic

care before they begin school (Rosenfelder, 1980; Jain, 1996). In this study the mean age of the children was  $4.88 \pm 2.52$  years. Some of them were about to begin primary school while the others were going to nursery school. When the reason for the delay of prosthetic treatment was enquired of the parents, it was seen that some had received insufficient and wrong advice such as the prosthesis could prevent the growing process. It was also determined that the family's financial resources played an important role in this delay especially in the case of lack of public insurance.

Results of the study showed that 33% of upper limb deficiencies consisted of longitudinal deficiencies and 54% of lower limb deficiencies were transverse. When one compares this results with the literature, it can be seen that this is an unusual finding (Bochman, 1981; Hirons *et al.*, 1991).

As we know in many other countries upper limb deficiencies are more common than lower limb deficiencies and the upper are predominantly transverse while the lower are predominantly longitudinal (Bochman, 1981).

In this study family history records showed that traditional marriages between close cousins were present in the parents of 8 (32%) children. Three (3) of them were the children with longitudinal upper limb deficiency, 3 of them had transverse lower limb deficiency and 2 of them had longitudinal lower limb deficiency. Due to this finding it can be said that there was probably a connection between the traditional marriages and longitudinal upper limb deficiencies while there was also a relation between the traditional marriages and transverse lower limb deficiency.

Although it is not possible to give accurate statistical data in such a limited number of patients, the outcome of this pilot study revealed that traditional marriages amongst close cousins are still popular in Turkey especially in the eastern parts and 52% of families have more than two children. This result shows the requirement of extensive community health programmes on family planning and pregnancy care.

At the end of the rehabilitation period, the limb deficient children reached a functional activity level. However, 2 children using transfemoral prostheses showed certain gait deviations such as abduction gait and wide step

width. Since they were given trans-femoral prostheses without knee joints, this was an expected result. After an adaptation period to the prostheses, these deviations were corrected by using knee joints.

In the upper limb group 41.6% were completely independent while 33.3% required self-help devices for independence. The self-help devices were designed for especially holding spoons and forks because of the difficulty in grasping such thin objects by the terminal device. Some 25% of the children (1 phocomelia, 1 shoulder disarticulation, 1 ulnar deficient child who had an ankylosed elbow joint) required assistance from someone else and used prostheses for assistance purposes because of the severity of malformations. Another reason for this tendency probably arises from the family's over protective attitude.

The authors are continuing to evaluate and rehabilitate new patients with limb deficiencies, and hope to gather more comprehensive data in the future.

On the basis of this study it can be concluded that succeeding in rehabilitating limb deficient children is a true challenge. With well-fitted prostheses and rehabilitation at a suitable age many children can learn functional skills and can find the opportunity of living equally with their peers.

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