

Function after through-knee compared with below-knee and above-knee amputation

E. HAGBERG, Ö. K. BERLIN and P. RENSTRÖM

Department of Orthopaedics, Sahlgren Hospital, University of Göteborg, Sweden

Abstract

Fifty-nine amputees, 24 below-knee (BK), 17 through-knee (TK) and 18 above-knee (AK) who had prosthetic replacements, were evaluated using a questionnaire which provided a quantitative and qualitative assessment scale for the prosthetic function.

The ability to apply or don the prosthesis was noted in 100% of the BK, 70% of the TK and 56% of the AK amputations ($p < 0.001$). Daily use of the prosthesis was recorded in 96% of the BK, 76% of the TK and 50% of the AK amputations ($p < 0.001$). A higher level of amputation resulted in a significantly lower degree of rehabilitation ($p < 0.05$).

The qualitative evaluation shows that the higher the level of amputation, the lower the usefulness of the prosthesis. Four percent of the BK, 12% of the TK and 39% of the AK amputees had no use whatsoever of their prosthesis ($p < 0.01$).

From a functional standpoint, TK amputation should always be considered as the primary alternative to AK amputation when a BK amputation is not feasible.

Introduction

Good surgical results after through-knee (TK) amputation have been reported since the 1950's (Batch *et al.*, 1954; Early 1968). The operative technique is described in more recent publications by Baumgartner (1979), Jansen and Jensen (1983), Jensen *et al.* (1982), Burgess (1977) and Stirneman *et al.* (1987). Despite good results, this amputation level is still frequently neglected. One reason is that it is

inevitable that the knee construction makes the femoral part of the prosthesis comparatively longer and the lower part consequently somewhat shorter compared with the normal leg (Jensen *et al.*, 1982; Mensch, 1983). When the patient is sitting, the prosthetic knee joint protrudes compared with the normal side (Fig. 1). Another important point is that the number of wound-healing complications after a TK amputation is higher than after an above-knee (AK) amputation, with delayed healing or re-amputation as the result. The reported frequency of re-amputation after TK amputation varies between 10 to 27% (Stirneman *et al.*, 1987; Jensen *et al.*, 1982; Baumgartner, 1979). There are, on the other hand, several studies reporting the advantages of TK amputation as compared to AK amputation (Stirneman *et al.*, 1987; Baumgartner, 1979; Jensen *et al.*, 1982; Burgess, 1977). Studies by Stirneman *et al.* (1987) and Houghton *et al.* (1990) emphasise

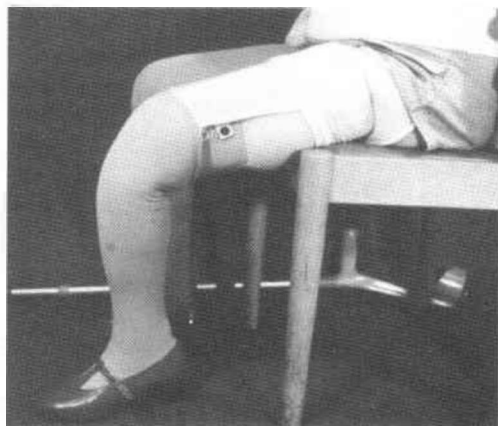


Fig. 1. In a sitting position, the prosthetic knee joint protrudes more on the side of the TK amputation compared with the normal side.

All correspondence to be addressed to Kerstin Hagberg, Gäskolan, Hjälpmedelscentrum, St. Sigfridsgatan 85, S-412 67 Gothenburg, Sweden.

that TK amputation should be performed when the clinical indications of wound-healing for the below-knee (BK) level are severely reduced.

At the Orthopaedic Workshop and Rehabilitation Centre for leg amputees in Gothenburg, Sweden, the number of TK amputees steadily increased between the years 1985 and 1987. This study was initiated to evaluate the rehabilitation of these patients compared with patients amputated below or above the knee. The purpose of this study is to evaluate the functional ability and the emotional acceptance of the prosthesis among patients subjected to TK amputation compared with BK and AK amputees.

Patient selection criteria

All the patients who underwent a TK amputation and were fitted with prosthetic replacements at the Gothenburg Orthopaedic Workshop and still were alive on December 31, 1987 constituted the basis of the patient selection. To obtain a homogeneous population, patients younger than 50 years and those who had been amputated more than 5 years ago were excluded, as were patients who underwent bilateral amputation. Patients suffering from another severe disease or handicap to the extent of being bed-ridden or totally limited to wheelchairs were also excluded. Finally, blind patients and patients with severe visual disturbances were also excluded, as were patients who could not communicate in Swedish.

Nineteen patients who underwent TK amputation fulfilled all the criteria. All the patients who underwent AK or BK amputation, who had visited the Orthopaedic Workshop between 1986-1987 and who fulfilled the above criteria were included in the control groups. This resulted in a total of 25 AK amputees. From the larger group of BK amputees who satisfied the same criteria, 25 were randomly selected to participate in this study. The total number of patients in the study was therefore 69.

Material

Ten patients were excluded for reasons which became apparent during the study; 1 BK (did not wish to participate), 2TK (1 deceased, 1 developed severe disease), and 7 AK (2 deceased, 2 developed severe diseases, 1 became a bilateral amputee, 1 gave up the

prosthesis after a short time, 1 did not wish to participate). Of the remaining 59 patients, 24 were BK (12 men/12 women) with a mean age of 74 years (53-87), 17 TK (9 men/8 women) with a mean age of 74 years (53-82), and 18 AK (12 men/6 women) with a mean age of 71 years (54-85).

Vascular insufficiency (including arteriosclerosis and diabetes) was the most common cause of amputation in all groups; BK 88%, TK 82% and AK 83%. The patients were fitted with the prosthesis the rehabilitation team regarded as being most suitable. Of the 24 BK amputees, 17 (71%) had a PTB (Patellar Tendon Bearing) prosthesis, 5 (21%) had a KBM (Kondylen Bettung Münster) prosthesis, and 2 (8%) had a PTS (Prothese Tibiale Supracondylienne) prosthesis. Of the 17 TK amputees, 15 (88%) had a Gothenburg model of the TK prosthesis (Fig. 2). This prosthesis has an open cuff with a medial frame, a dynamic lateral condylar anchorage and a polycentric knee joint. Two patients (12%) had a conventional TK prosthesis with a leather cuff and a hinge joint. Of the 18 AK amputees, 13 (72%) had a suction socket prosthesis and 5 (28%) had a detachable cuff used for elderly patients.

Methods

All the patients were interviewed in person by the same author (KH). Before the interview, the patients were informed about the study and asked for their voluntary, anonymous participation. At the time of the interview, the amputee had used the prosthesis for a minimum

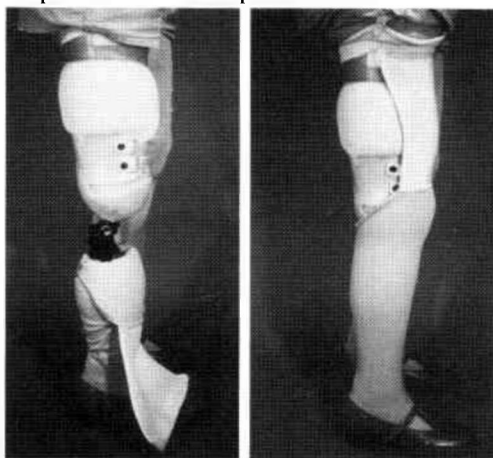


Fig. 2. Prosthetic replacement after through-knee amputation.

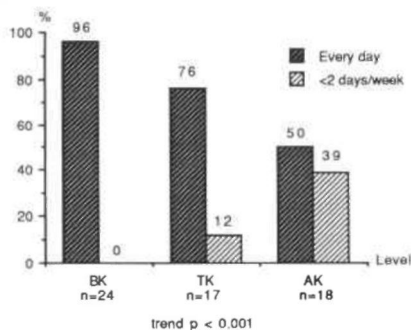


Fig. 3. Distribution (percent) of amputees who use the prosthesis every day and less than two days per week respectively in relation to the level of amputation.

of 6 months. A questionnaire, which was partly inspired by Day's protocol for the examination of amputee activities, was constructed for the interview (Day, 1981). The questionnaire is subdivided into three sections. The first section contains personal data, the second section describes the prosthetic rehabilitation, and the last section evaluates the patient's subjective assessment of the prosthetic replacement. In the last section the answers are graded on a scale of 1-7.

The results have been computerised and the following statistical methods have been used; mean and median values, Chi-square test with Yate's correction and Chi-square trend for proportions by Armitage (Armitage, 1974).

Results

At the time of the interview, the TK amputees had had their prosthetic replacements on average for a shorter period of time than the other two groups; TK 17 months versus BK 26 months and AK 39 months.

Seventeen percent of the BK amputees reported a fear of their prosthesis loosening, the corresponding figures for TK and AK were

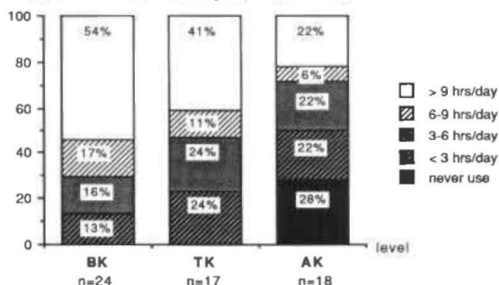


Fig. 4. Distribution (percent) of numbers of hours per day the amputee uses the prosthesis in relation to the level of amputation.

18% and 41% respectively. In order to retain the prosthesis, a suspension with a band around the waist was necessary in 4% of BK, 6% of TK, and 44% of AK ($p < 0.05$). Thirty-three percent of BK, 6% of TK and 17% of AK reported that they sometimes or always had to bandage the stump in order to be able to apply the prosthesis. Fifty percent of the BK amputees reported that they sometimes or always had pain using the prosthesis, compared with 35% for the TK and 68% for the AK.

The quantitative use of the prosthesis per week is described in Figure 3. Daily prosthesis use declined with rising levels of amputation ($p < 0.001$). Five of the AK amputees (28%) did not use their prosthesis at all. All these patients had used their prosthesis for a minimum of 6 months, but had abandoned their rehabilitation after that. Figure 4 describes the number of hours per day the patients used their prostheses. Thirty-three percent of the BK amputees reported that they often or always used a wheelchair indoors compared with 63% of the TK amputees and 56% of the AK amputees (n.s.). When it came to walking aids, 67% of the BK, 18% of the TK and 28% of the AK were able to care for themselves without these aids or only needed one crutch/cane while walking indoors. The difference between BK and TK is statistically significant ($p < 0.05$). Two crutches or a walker were used by 33% of the BK, 82% of the TK and 44% of the AK amputees. Approximately 80% of the patients, independent of amputation level, were able to return to their homes. The rest of the patients lived in apartments for the elderly or disabled.

The functional evaluation of the three different groups of amputees is presented in Figure 5. This section of the questionnaire was answered with a "yes" or "no". It was statistically significant (Chi-square trend for proportions by Armitage) that the higher the level of the amputation, the lower the proportion of patients who were able to apply the prosthesis alone ($p < 0.001$) and the lower the number of patients who were able to travel in an ordinary car ($p < 0.05$).

The cumulative degree of rehabilitation was rated using a system where five different functions were weighted differently (Fig. 5); prosthetic application 10 points, walking outdoors 7 points, walking up/down stairs 5 points, travelling by car 5 points, managing

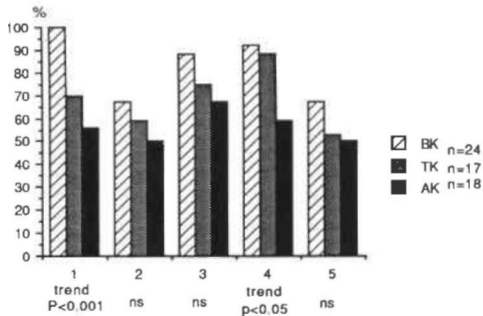


Fig. 5. Grade of rehabilitation among prosthesis users in relation to the level of amputation. The bars describe the distribution (percent) of patients with the described functional ability.

The number (1-5) relates to the ability to perform the following functions with the prosthesis:

1. apply the prosthesis
2. walk outdoors
3. walk up and down stairs with support of the handrail and a crutch
4. travel in a car
5. perform easy household chores (washing up, light cleaning, watering plants)

simple housework 7 points. The results were analysed using a computer and the trend showed that the higher the level of amputation, the lower the degree of rehabilitation ($p < 0.05$). The female patients performed on average more poorly than the male patients.

The results of the qualitative evaluation are described in Figure 6. The higher the level of amputation, the higher the proportion of patients with moderate to severe difficulty applying the prosthesis ($p < 0.001$). In a similar way, the patients with a higher level of amputation had more problems visiting the lavatory compared with amputees with lower levels of amputation ($p < 0.001$).

Four percent of the BK amputees reported that they had no use of the prosthesis whatsoever, the corresponding figures for TK and AK amputees were 12 and 39% respectively. The trend for the prosthesis not to influence the amputee's activities of daily living was higher the lower the level of the amputation ($p < 0.01$).

Qualitative-scale
(median value)

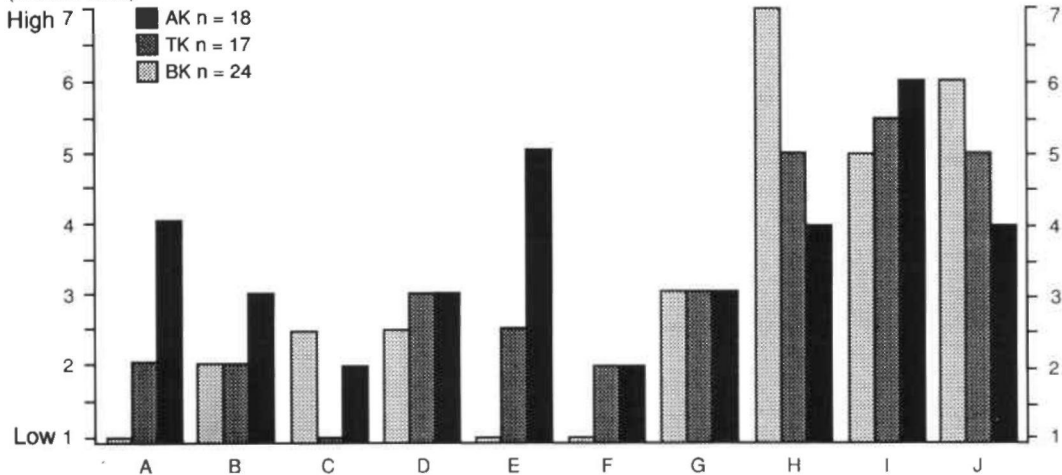


Fig. 6. Qualitative functional evaluation of the three different levels of amputation expressed as the median value on a rating scale of 1-7.

Qualitative rating among prosthesis users regarding:

- A. difficulty for the patient to apply the prosthesis
- B. how strenuous it is to walk 25 metres indoors
- C. pain when using the prosthesis
- D. awareness of the weight of the prosthesis
- E. difficulty in sitting on the lavatory*
- F. discomfort of sitting in an ordinary chair**
- G. getting out of an ordinary chair**
- H. value in activities of daily living
- I. prosthetic design***
- J. overall prosthetic function

* 2/24BK, 1/17TK, and 5/18 AK never used the prosthesis while visiting the lavatory.

** 1/24 BK, 4/17 TK, and 3/18 AK never sat in ordinary chairs with the prosthesis.

*** 1/17 TK could not answer the question.

Discussion

The advantages of BK amputation compared with AK amputation have previously been reported (Kegel *et al.*, 1978). The energy consumed by walking with the prosthesis is less and the walking velocity higher (Walters *et al.*, 1976). The TK amputee with a prosthetic replacement has also been reported to have several advantages as compared to the AK amputee. Since the distal femur is left intact, the stump tolerates weight-bearing more effectively (Liedberg, 1982; Hughes, 1983). The shape of the stump permits the simplified suspension of the prosthesis, which is consequently easier to apply compared with an AK prosthesis. Since most of the muscle compartments around the hip joint and the distal end of the femur are intact, there is no muscle imbalance, thereby resulting in a decreased risk of reduced motion of the hip joint. Furthermore, the long lever arm results in a good prosthetic gait with better balance and control of the prosthesis (Stirnemann *et al.*, 1987; Baumgartner, 1979; Jensen *et al.*, 1982; Burgess 1977). The development of various new types of polycentric knee construction (Öberg, 1983) and new types of prosthetic cuff have also improved prosthetic replacements after TK amputations. Stirnemann *et al.* (1987) reported that 84% of the BK, 66% of the TK, and 22% of the AK amputees in their study were "fully rehabilitated and regained their physical and psychic independence". In a Danish study, Jensen and Mandrup-Poulsen (1983) report that 72% of the BK, 69% of the TK and 41% of the AK amputees who had been discharged from the hospital "achieved an outdoor walking capacity". These findings agree well with the present study.

Fewer of the TK amputees than the AK amputees were afraid of being unable to retain their prostheses in the present study, and a significantly smaller proportion of the patients needed a waistband on the prosthesis. The TK prosthesis attachment with the dynamic anchorage above the femoral condyle resulted in a safe suspension. Furthermore, only 1 of 17 TK amputees needed to bandage the stump before applying the prosthesis. Experience shows that bandaging the stump after the TK amputation is often unnecessary. Likewise AK amputees with prosthetic replacements with an adjustable socket did not need to bandage the

stump. It is interesting to note that the TK amputees reported less pain when using the prosthesis compared with AK amputees and BK amputees. This may be explained by the surgical technique of not using osteotomy at TK amputation and the favourable prosthetic suspension permitted by the femoral condyles.

Although no patient in this study was amputated more than 5 years ago, the TK amputees had not had their prostheses as long as the other two groups. This could possibly explain why as many as 82% of the TK amputees were using two crutches or a walker. Since the interview, some of the patients at the Rehabilitation Centre have improved their gait ability and, in some instances, have stopped using walking support after continued rehabilitation. The amount of wheelchair use has also been reduced in some cases. In the qualitative assessment, some patients reported that they had never tried to use the prosthesis when visiting the lavatory or sitting in ordinary chairs. Most of these BK and TK patients had not had their prostheses for more than 6 months. Of the AK amputees, all the patients with the corresponding disability had had their prosthetic replacements for more than 12 months (Fig. 6).

When it comes to the inability to apply the prosthesis, it is known from experience that the TK amputees need only a slight amount of help, something a relative of the same age as the patient can usually cope with. For the AK amputee with a suction socket prosthesis, professional help is usually required. Since more than 75% of the patients still live in their own homes, the ability to climb stairs and travel by ordinary car plays an important part in personal freedom. This study shows that the higher the level of the amputation, the less the tendency to master these abilities. Patients with unsuitable flats who do not master these functions are largely imprisoned in their homes.

It has been thought that TK patients have a low prosthesis acceptance for cosmetic reasons (Fyfe, 1990). In this study, there was no difference in the level of cosmetic acceptance between the different groups. One reason could be that the better the grade of rehabilitation and activity level of the patient, the greater the demands imposed on the cosmetic appearance of the prosthetic device. When analysing which subgroups reported dissatisfaction with the

appearance of the prosthesis it was found that women with BK amputation were most dissatisfied (58% low acceptance). One probable reason for this is the difficulty of achieving a sufficiently slim prosthetic ankle.

While the results of this study suggest functional advantages for the TK compared with the AK amputation, the size of the study population limits some of these observations to statistical trends rather than statistically-significant differences. One of the major difficulties in obtaining a sufficient patient population is the high death rate and the occurrence of concurrent diseases which frequently afflict patients undergoing lower limb amputations (Kihn *et al.*, 1972).

TK and AK amputations are sometimes considered to be equivalent procedures since both required prostheses with mechanical knee joints (Fyfe, 1990; Beekman and Axtell 1987). This study, however, shows that there are significant differences in function for patients with TK and AK amputations:

the TK amputee uses the prosthesis more frequently than the AK amputee;
the TK amputee has a higher degree of rehabilitation than the AK amputee;
the TK amputee has more daily use of the prostheses compared with the AK amputee.

Thus, from a functional standpoint, TK amputation should always be considered as the preferred alternative to AK amputation when a BK amputation is not feasible (Stirnemann *et al.*, 1987; Houghton *et al.*, 1990).

Acknowledgements

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