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Locomotion of the hemipelvectomy amputee

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Abstract

Among the fifteen patients with hemipelvectomy who were treated in our clinic since 1965, five amputees have used a prosthesis. Their ambulatory function depending upon the condition of each stump and its ability to tolerate socket pressures.

A locomotion study was performed on a female aged thirty who had had a tumour in her pelvis and underwent a resection of the left ischium, pubis, and half of the iliac bone. A moulded total-contact socket with partial weight bearing on the residual iliac bone, with a Canadian-type prosthesis was fitted. During partial weight bearing with crutches, she demonstrated good walking posture. However, her stump dropped off in the stance phase because of unstable fitting.

The results of this gait analysis were as follows;

1) Joint motion: The prosthetic hip flexed very little, the knee joint flexed forty degrees in the swing phase during comfortable walking. In the sound side, at push off, the hip was extended to twenty-five degrees in combination with twenty degree knee flexion and forty degree plantar flexion of the ankle.
2) Ground to foot force: About eighty per cent of body weight was supported by the prosthetic foot in crutch walking. Approximately the same length of time passed on both feet during stance phase.
3) Progression of the centre of pressure: The locus of pressure point on the sound foot demonstrated an early shift to the forefoot.

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Introduction

The problem of malignant tumours in bone and soft tissue of the lower limb is well known and has been discussed in many articles from the pathological and therapeutic aspects. However, from the point of view of rehabilitation this problem has received little attention up to the present time.

Since the report deals with the hemipelvectomy prosthesis, we are primarily concerned with the treatment of malignant disease in the highest level of the lower extremity. It is clear from the literature that surgical treatment is indicated for the patient who has malignancy in the lower extremity even if this is located at a higher level than the hip joint (Higinbotham *et al*, 1966; Pack and Miller, 1964).

During the past ten years, fifteen patients underwent a hemipelvectomy amputation in our university and affiliated hospitals due to malignant tumours, ten of these patients have survived.

Existing medical treatment for malignant bone tumours is to use chemical agents even after surgical intervention. When intensive medical treatment is performed after amputation prosthetic fitting is severely affected by the undesirable side effects of chemotherapy: fitting of a final prosthesis may be delayed due to oedema of the stump.

Five patients have been fitted with prostheses; their ambulatory function depends upon their general health, age, and the local condition of their stumps.

If the patient has the ischial bone, it can be used to bear his weight in the classical Canadian-type socket prosthesis and can maintain smooth ambulation (McLaurin 1970, Solomonidis, 1977). However, if he does not have a good bony stump for weight bearing, several modifications are necessary to the prosthetic socket in order that the pressure may be tolerated through the broad soft tissues (Wade and Macksood, 1965).

The case presented shows a representative record of the subject with hemipelvectomy amputation wearing a modified Canadian-type prosthesis.

Subject and equipment

The patient is a thirty year old housewife. A tumour in her pelvis was diagnosed as chondrosarcoma and hemipelvectomy (resection of left ischium, pubis and half of iliac bone) was carried out.

A moulded total contact socket and modular hip disarticulation prosthesis was fitted, using a Canadian-type hip joint, and uniaxial knee joint with SACH foot (Figure 1).

A locomotion study was performed. Information was obtained from hip, knee and ankle goniometers (Figure 2) and a force analysis was carried out between the foot and the ground showing the locus of pressure point in the stance phase against time.

Goniometers were applied to the patient and prosthesis at the axis of the joints. The force patterns between the foot and ground were composed of the three components of force which developed vertically (Z, positive, on the foot), horizontally along the line of progression (X, positive, backward on the foot), and horizontally at right angles to the line of progression (Y, positive, medially on the foot).

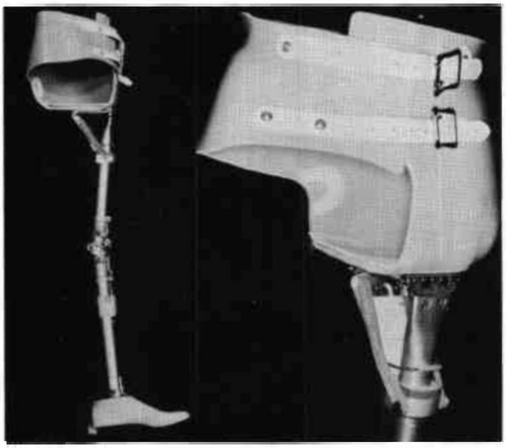

Fig. 1. Left, modular hip disarticulation prosthesis. Right, total contact socket.

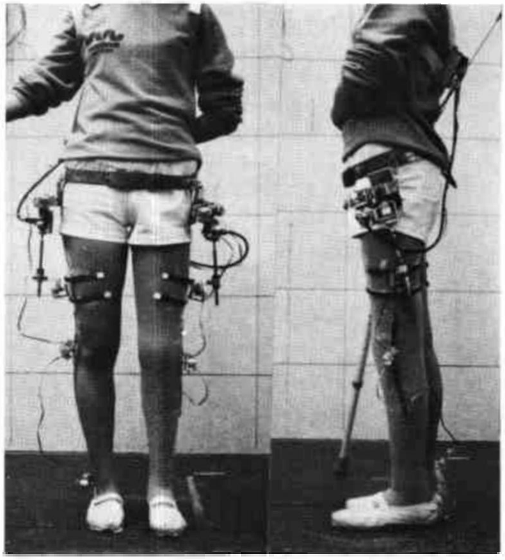

Fig. 2. Patient with hip, knee and ankle goniometers in place.

Results and discussion

Joint motion

The hip joint axis of the goniometer was placed on the point of supposed physiological joint axis which was symmetrical to the sound side. The knee and ankle movements were also measured at the same time during the level walking.

The results can be seen in Figure 3. The left prosthetic hip is flexed very little in the swing phase and the knee joint is flexed only in the swing phase monophasically to about forty degrees. The right hip flexion is forty degrees in the swing phase and thirty-five degrees at heel contact. At the time of right push-off the hip is extended to twenty-five degrees in combination with twenty degree knee flexion and forty degree plantarflexion of the ankle. The knee flexion movement on the right is seen during the stance and swing phases biphasically, however, this figure is different from the normal movement pattern in the period of the middle stance phase. This abnormal flexion of the knee joint is connected with the ankle movement, which shows a characteristically rapid plantarflexion at mid-stance and a highly plantarflexed position at the end of the stance phase.

The gait deviation demonstrated by the early and excessive plantarflexion of the sound foot is classified as a vaulting ambulation. There is also

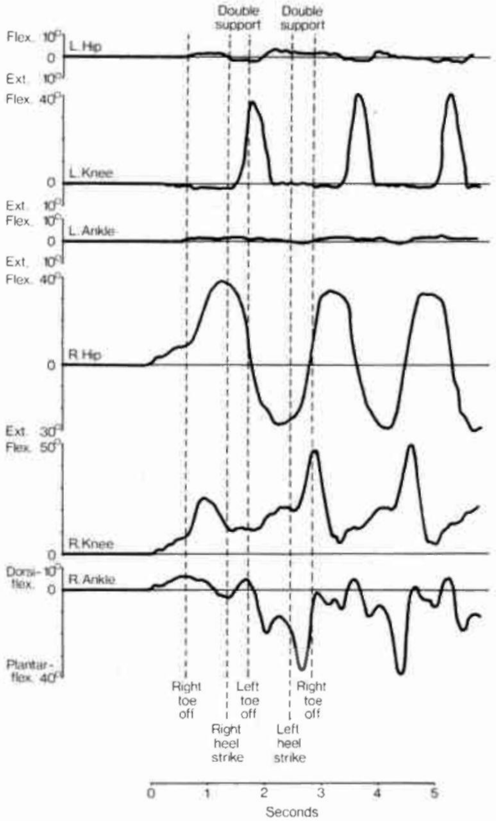

Fig. 3. Joint motion in level walking. The prosthesis is on the left.

some lumbar lordosis at push-off when the subject reaches sufficient step length with the prosthesis. The sound hip extension associated with the increased ankle plantarflexion is noted in contrast with no movement of the prosthetic hip at the period of double support.

Ground to foot force

The resultant force on the floor is seen in Figure 4. The upper trace represents the vertical force between the foot and the ground of two successive steps. It demonstrates that about eighty per cent of the body weight is supported by the prosthetic foot during crutch walking. The time scale shows approximately the same length of time passed during the stance phases of both feet. The stance phase of the prosthetic foot becomes shorter if walking is aided by only a single crutch (Figure 5). It is noted that in this pathological gait the graphical recordings of vertical force of the sound side do not show such smooth waveforms as is found in the normal subject.

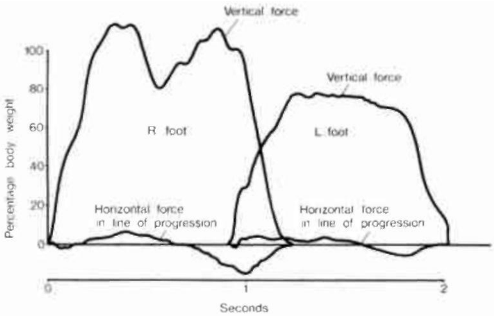

Fig. 4. Ground to foot force, walking with two crutches.

The lower curve in the figure represents the horizontal forces in the line of progression. The force is forward at heel contact and backward at toe-off. The force is smaller in the prosthetic foot than in the sound side.

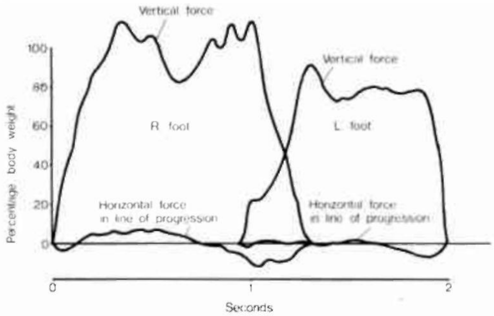

Fig. 5. Ground to foot force, walking with one crutch.

Progression of the centre of pressure

Figures 6 and 7 show the locus of the pressure point of the foot. The trace is the path followed by the centre of pressure of the foot over the surface of the force plate and relative to the whole foot print, which is superimposed. The points on the curve are at equal intervals of one tenth of T, which is the time duration of the stance phase of each leg.

Immediately after heel-strike there is a rapid progression forward of the centre of pressure on the sound right foot. The first peak of force on the ground is reached when the metatarsal heads first make contact with the plate (foot-flat).

The whole load is then taken on the forefoot for a relatively long period as compared to heel contact as can be seen by the positions of the time-markers. The magnitude and duration of force in this area suggests that the forefoot is

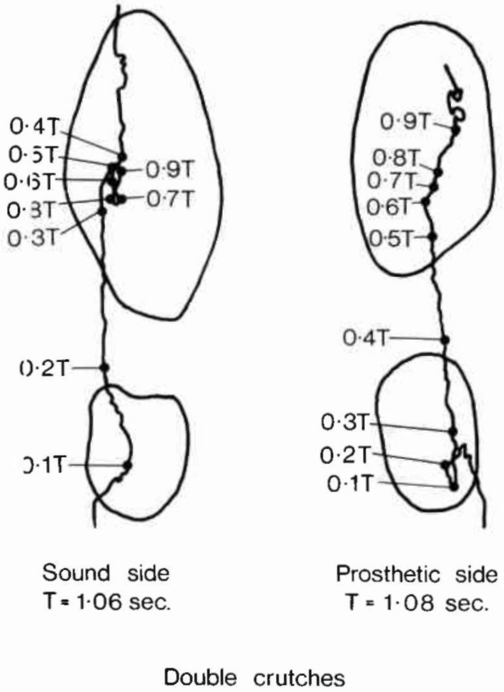

Fig. 6. Progression of the centre of pressure, walking with two crutches.

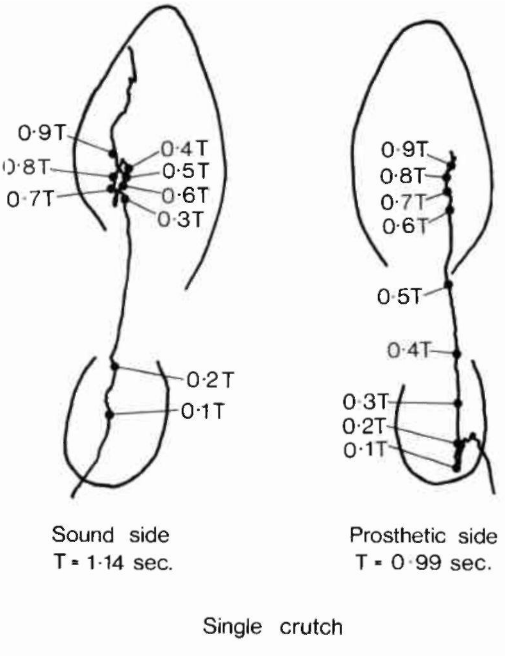

Fig. 7. Progression of the centre of pressure, walking with one crutch.

much more important than the hindfoot in transferring force. In the prosthetic foot, on the contrary, the centre of pressure moves slowly forward after staying for long time on the SACH heel (Figure 6).

When the patient walks with a single crutch these features are also demonstrated (Figure 7). T is longer on the sound foot and shorter on the prosthetic foot. The period of double support is prolonged on both sound forefoot and prosthetic heel.

Vertical movement of the stump in the prosthetic socket was measured from X-ray films which were taken in both the stance and swing phases. When the subject was walking with one crutch. It was found to be approximately 2 cm.

The unstable fitting of this stump in the socket may be one of the causes for taking a long period of double support as when transferring the weight to the prosthetic foot.

Summary

A locomotion study was performed on a hemipelvectomy amputee wearing a prosthesis.

The experimental arrangement described in this paper, combining joint motion developed during walking, a computer analysis of the force pattern between the foot and ground and plotting of pressure point on the foot print, has enabled detailed investigation with demonstration of several abnormal features in the prosthetic gait of a hemipelvectomy amputee.

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