Prosthetics and Orthotics International, 1982, 6, 88–92

Frame type socket for lower limb prostheses

R. VOLKERT

Orthopaedic Department, University of Mainz

Abstract

The technique presented uses a frame-type socket for fixation of the prosthesis on the stump. Apart from rigid areas for stabilization and control, the soft tissue of the stump is enclosed by flexible material. This allows self-adjustment of the socket to changes in stump circumference and volume, while maintaining good socket fit.

Introduction

Prosthetic care for lower limb amputees presents a highly complicated problem particularly in the period immediately following the amputation. While still being shocked by the very fact of amputation and having to accept impairment of his visual appearance and the loss of essential body functions as a new fact of life, the patient develops individual expectations with regard to the future handling of his problem. To meet these expectations the prosthetist has to provide a prosthesis which not only re-establishes the lost body functions but also provides a visual and tactile appearance similar to the amputated limb. Much progress has been achieved in this context during the last years by the modern functional and cosmetic technology of modular prostheses. There still remains, however, a considerable deficiency in stump accommodation techniques.

Early prosthetic care is in the interest of all participants for functional rehabilitation. To this end there should be a controllable, undisturbed wound healing process and enclosure of the amputation stump into the most favourable mould which takes account of its anatomical and pathological circumstances. This latter requirement, in particular, is difficult to fulfil in the case of first or early prosthetic fitting, as postoperative changes in volume and circumference of the stump with enclosure or pressure dressings cannot be avoided (Fig. 1).

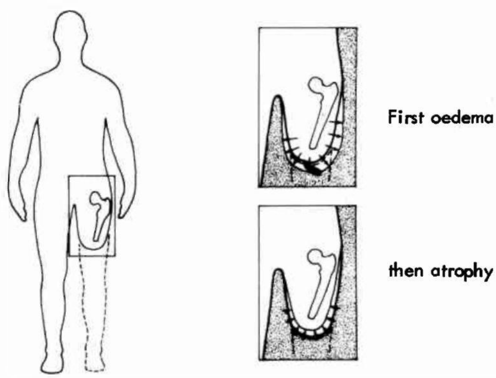

Fig. 1. Variation of volume in the amputation stump.

Consequently, the changes arising in the form and volume of the stump are not taken into account by the socket in conventional techniques. The functional value of a prosthesis being predominantly determined by the accurate matching of the socket to the stump, this problem is of particular importance.

In the techniques of suspension that are employed to date using suction or total contact sockets, the best, first or early prosthetic fitting can only be achieved by permanent correction (widening or narrowing) of the prosthetic socket (Fig. 2).

All correspondence to be addressed to Mr. R. Volkert, Head of the Technical Orthopaedics Laboratory, Orthopaedic Department, University of Mainz, Langenbeckstr. 1, D-6500 Mainz, West Germany.

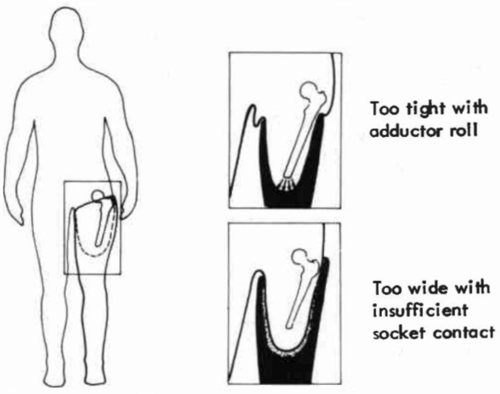

Fig. 2. Socket fitting deficiencies.

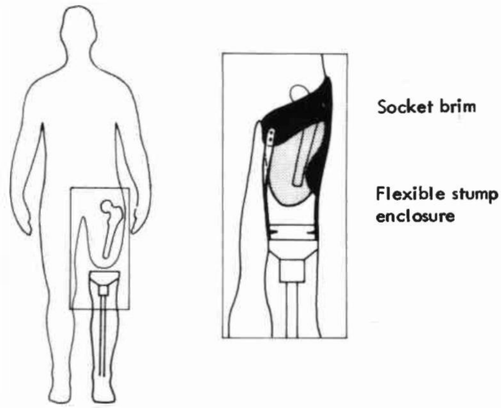

Fig. 3. Socket brim, femoral clasp and connection to prosthesis.

Some discrepancies can certainly be handled by belt systems on a short term basis. This, however, implies for the patient a continuous dependence on the orthopaedic technician up to the time when the amputation stump has attained its permanent shape.

Various efforts had been made in order to avoid this disadvantageous situation. Sockets have been developed, for instance, which compensate for stump volume changes by the use of inflatable air cushions (Kuhn, 1959; Biedermann, 1979).

This study reports an attempt to enclose the stump in a specially designed frame socket; the technique is described in some detail below.

Frame socket accommodation of above-knee and hip disarticulation stumps

Using the fact that the proximal part of the amputation stump exhibits the smallest variations in volume, in most cases a precise enclosure of the upper part can be attained by a closed proximal socket brim (Fig. 3). From this brim the load-bearing framework with its struts of elastic material extends distally to form the connection with the knee part of the prosthesis. The soft tissue, with its disposition to circumferential variations, is largely bypassed by this technique.

Several modifications of frame construction have been tested. A three-sided soft tissue release towards the ventral, medial, and dorsal direction has been preferred as it offers advantages both for the patient's comfort and the prosthetic fitting (Fig. 4). Moreover, criteria were considered which, at the present time, are estimated to be most advantageous for the accommodation of the above-knee stump and which have been excellently realised in the total contact socket (Hepp, 1948; Kuhn, 1963–68) with terminal contact, femoral clasp, and proximal brim (Fig. 5).

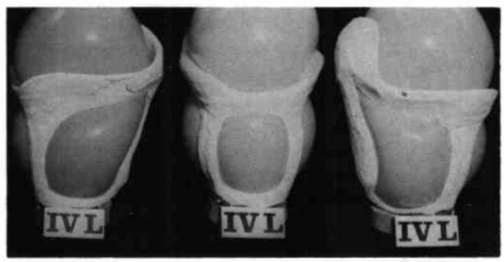

Fig. 4. Plaster cast frame socket, ventral, medial and dorsal views.

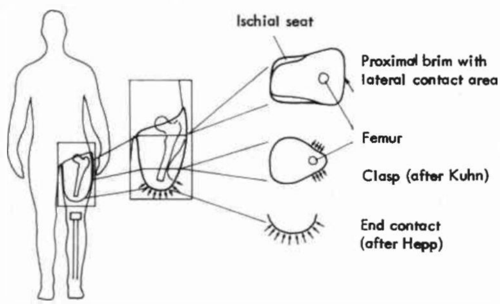

Fig. 5. Special properties of the total contact socket.

Taking into account these particular accommodation properties, there is in the frame socket, in the region of the fascia lata, a wide strut with the femoral clasp extending distally to the knee part of the prosthesis. Depending on the properties of the stump, the desired terminal contact is obtained by elastic fabric, a foam material cushion, or solid materials. The soft tissue (which is particularly subject to volume variations) protruding from the ventral, medial, and dorsal frame openings is accommodated in two different ways by elastic compression (Fig. 6). The elastic enclosure of these parts of the stump, which are not compressed by solid material, is necessary in order to avoid oedematous swellings.

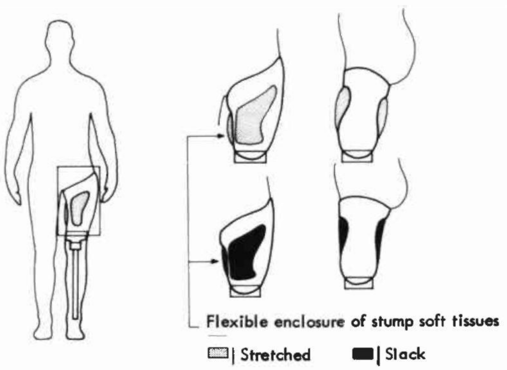

Fig. 6. Frame type socket demonstrating flexible enclosure of stump soft tissues.

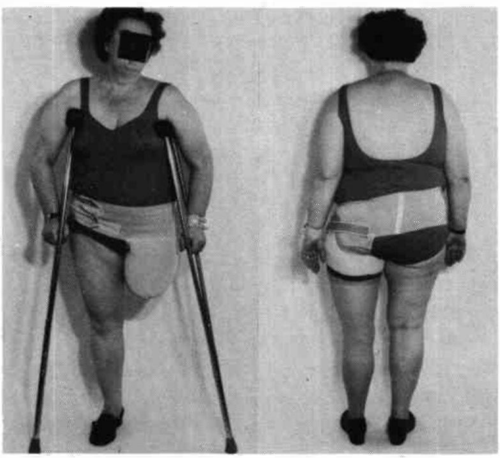

Fig. 7. Left, patient with stump compression bandage. Right, same patient wearing prosthesis with frame socket.

The first procedure comprises the compression of the stump by an elastic stocking which can be put on comparatively easily with the aid of a lateral zip-fastener (Fig. 7). Donning of this compression stocking is facilitated by an understocking. A lateral part which runs along the thigh and is fixed to the pelvic region guarantees a perfect fitting even after prolonged wear and operation. The prosthesis with the frame socket is put on in the conventional way over this compression stocking which completely sheathes the amputation stump (Fig. 8).

Fig. 8. Patients with frame socket prostheses. Left, resin cast, right, plaster cast.

In the second approach the system is modified so as to first introduce the stump into the frame socket as usual. The soft parts of the stump which protrude from the openings are elastically enclosed by a double traction stocking which is fixed at the upper socket rim and is drawn downward over the outside of the socket (Fig. 9). This technique can only be employed in frame sockets with thin walls, however, as there would otherwise be a discontinuity in the uniform enclosure. The prosthetic cosmesis which is pulled up after donning the prosthesis is fixed by a Velcro fastener to the distal region of the frame socket.

The two procedures outlined above enable the sheathing of most stump volumes and a consequent self regulation of variations in volume and circumference by the elastic framing and enclosure of the soft tissue of the stump.

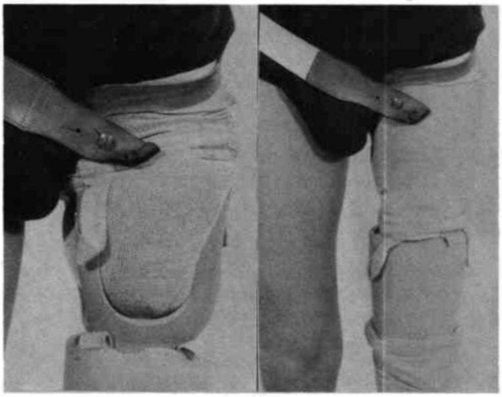

Fig. 9. Frame socket enclosure of an above-knee stump by an outer compression bandage.

Moreover, the patient is able to put on his prosthesis without problems as the openings in the frame socket allow a manual and tactile contact with the stump surface and hence accommodation of the stump into the socket without strain.

As a result of favourable experiences in the care of above-knee amputees this techniques was used also for the construction of hip disarticulation prostheses. To this end the prosthesis is fixed at the pelvic stump by a miniature pelvic basket (Fig. 10), while the voluminous soft parts are enclosed by a slightly or moderately compressing TIGGES* bandage without however using a back pad (Fig. 11). Apart from guaranteeing good functioning of the prosthesis it is more comfortable for the patient as a result of the elastic control of the device.

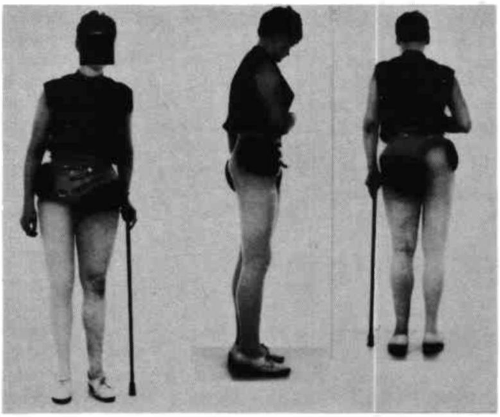

Fig. 10. Hip disarticulation prosthesis with miniature pelvic basket.

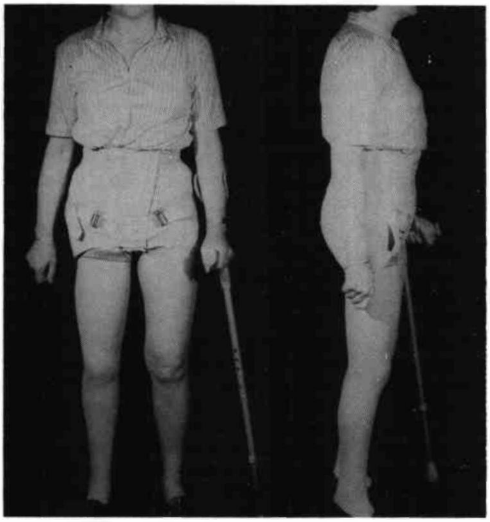

Fig. 11. Hip disarticulation prosthesis with miniature pelvic basket and TIGGES bandage applied.

There are no essentially new guidelines for the experienced orthopaedic technician to be considered in the construction of this type of prosthesis, as the frame socket is fixed to the prosthesis modules in the same way as conventional sockets.

The frame socket itself is designed on the basis of an individual plaster mould of the amputation stump that is converted to a plaster positive. This positive serves for the construction of a plastic socket, which is then provided with the necessary openings to yield the desired frame pattern. The completed frame socket is fixed in an appropriate way to the prosthesis modules.

In the course of production of the frame socket prosthesis the adaptation of the frame socket to the prosthesis by means of adjustment devices is an optional possibility for optimization of the system.

Results

A total of 23 patients were fitted with the new frame socket technique (14 above-knee amputees and 9 hip disarticulation patients). The patients unanimously rated the tactile contact between the amputation stump and the prosthesis and the visual appearance of the system as very agreeable. They reported no difficulties in the handling of the device. The

*Product of Otto Zours KG,
Postfach 480,
D–4320 Hattingen.

load bearing sensation in the frame socket due to its elastically supporting apertures, was unanimously reported to be most comfortable and free of any problems. The static and dynamic stability of the patients was in no case estimated as being inferior to that of patients provided with conventional devices. The new frame socket technique has also been applied to patients who had complained about their previous closed socket prostheses; these patients are now free of complaints.

Discussion

The technique of amputation stump accommodation described in this paper is a practicable alternative in the early care of amputees which offers the possibility of compensating for variations in stump circumference and volume. This is particularly necessary in the care of patients after tumour-indicated amputation as considerable variations in body weight and hence in stump volume are to be expected during the prolonged period of chemotherapy which in most cases follows the operation. Moreover, the elastic enclosure of the soft stump parts yields space for muscle contractions, avoids unnecessary perspiration and provides for ventilation of the amputation stump which adds to the patient's comfort. The large range of possible variations in the stump enclosure given by this technique enables early independence from the orthopaedic technician coupled with an optimum prosthetic fitting and adaptation. The correct donning and use of the prosthesis is simplified for the patient making a fast functional rehabilitation possible.

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