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Socket design and manufacturing technique for through-knee stumps

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Abstract

This paper describes a socket design and manufacturing technique for through-knee stumps, based on 14 years experience with 290 prostheses. The bulbous shape of the stump and its full end-bearing quality requires a socket which has very little resemblance to above-knee sockets. The requirements of the through-knee socket are listed and the manufacturing technique is described and illustrated in detail. Emphasis is put on the quality of the negative plaster mould. The socket is manufactured according to the double wall technique commonly used in below-knee sockets. It provides a maximum of comfort and cosmesis without extra costs.

Introduction

Since 1970, we have been faced with an increasing number of patients presenting uni- or bilateral through-knee (TK) stumps for various reasons. Previous designs with rigid sockets or with a leather corset were mere modifications of the above-knee (AK) socket. They were unable, or only partially able, to take advantage of the particular and superior qualities of the TK stump (Table 1). Furthermore, their comfort, cosmesis and resistance to wear and tear needed to be improved.

The socket for TK stumps has to meet the following requirements:

1. Total surface contact in both the sitting and in the upright position.
2. Total end-bearing quality; in normal anatomy the femoral condyles transmit full weight to the tibial plateau and vice versa.
3. No ischial seat and therefore free motion of the hip joint.
4. Easy doffing and donning with the patient in sitting position, requiring no extra physical and intellectual effort.
5. No straps, laces or suspenders.
6. No, or minimal, extra width or length compared to the normal anatomy of the thigh and the knee.
7. The socket should be able to be fitted with every type of knee joint designed for TK amputation including the possibility of knee locking or swing phase control.
8. No special adaptation of clothing, no extra wear due to the prosthesis.
9. Easy to clean for effective stump hygiene.
10. Minimum of weight without loss of durability with regard to the patient's activity.
11. Possibility to adapt the socket to changes of the stump shape and volume.

Table 1.

Stump	Knee disarticulation	Above-knee amputation
Thigh muscles	preserved	partially preserved
Bony outgrowth	impossible	possible
Lever	long	short
Shape	bulbous	conic
End-bearing	total	none (or partial)
Ischial bearing	none	total
Hip joint: range of motion	free	limited

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12. Standardized manufacturing technique requiring no extra skill from the prosthetist who is familiar with normal anatomy and current manufacturing techniques.
13. No extra costs compared with conventional prostheses.

Manufacturing technique

Plaster mould

The quality of the socket depends primarily on the quality of the negative plaster mould. Particular attention must be given to the anatomy of the stump end to enable the femoral condyles to transmit full weight on to the prosthesis as they did on the tibial plateau before amputation took place. Accordingly, a maximum amount of end bearing must be achieved in transcondylar TK stumps with reduced weight-bearing surface.

The casting method that has been practised for many years now is rather simple. The negative mould is taken with the patient lying on his back and holding his stump in a position of about 70 degrees of flexion. This provides more comfort and safety for the patient (and also for the prosthetist).

The skin is first covered with an ordinary elastic stocking tube (Tubigrip) sewn at its end and enlarged for the increasing circumference of the thigh at its proximal half. The negative plaster mould must present an exact replica of the shape of the stump. It is preferred to make the negative mould with elastic plaster bandages even though ordinary plaster bandages might also be used.

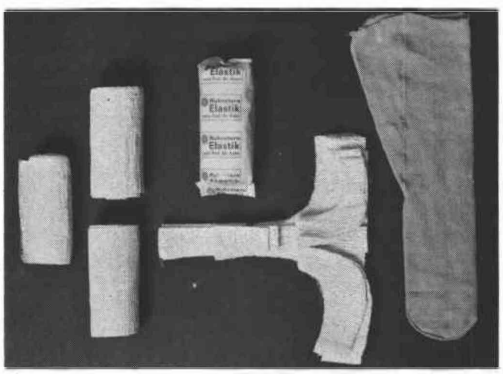

Fig. 1. Material needed for the negative plaster mould. Left, elastic plaster bandages. Centre, pre-cut plaster strips for the intracondylar notch and the dorsal supracondylar area. Right, Tubigrip stocking.

Fig. 2. Lateral view showing modelling of the supracondylar area and the intracondylar notch.

To begin with, several precut strips of plaster bandage are used to cover the end of the stump (Fig. 1). The first strip is applied in a sagittal direction to cover the intracondylar notch. The second strip is applied just behind the proximal border of the condyles and the patella. No external pressure is applied for modelling. As soon as these plaster strips are slightly hardened, more thin layers of plaster bandage are applied to cover the entire stump. Only then is a thin layer of circular plaster bandage added. This cast negative is now moulded with two hands, one gently modelling the intracondylar notch at the dorsal side, while the other provides a snug fit of the plaster cast just proximally to (and not on) the femoral condyles and the proximal end of the patella (Fig. 2). This part is particularly important because it is the only way to provide a really close anatomical fit. It can never be substituted by any sort of stump cushion. The upper end of the socket reaches to 2–3 cm up the groin. This seems to be necessary to control lateral and torque forces.

The positive cast thus gives a most accurate replica of the stump and does not need further correction.

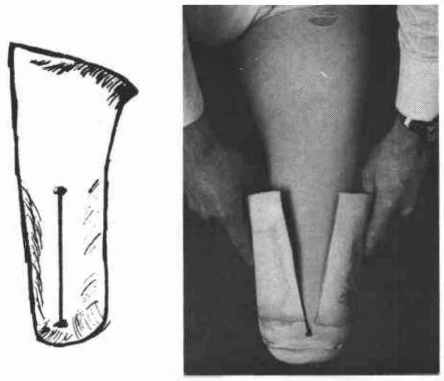

Fig. 3. Two types of soft sockets. Left, long type. Right, short type.

Socket

The double wall socket technique transforms the bulbous stump into a conic one. The inner liner acts as a cushion between the stump and the outer socket. It also permits the socket to adapt to further changes of shape and volume up to a certain limit.

The inner liner is made from polyethylene foam. In slim patients, it is preferable to make a soft socket which is somewhat higher than the outer socket. To permit easy doffing and donning, it is longitudinally split in the anterior part. To avoid tears, two holes of 8–10 mm diameter are punched at each end of the slit (Fig. 3, left).

In obese patients and in order to improve cosmesis, the inner liner is limited to the distal half of the stump (Fig. 3, right).

The outer socket is rigid only in its distal half; it becomes gradually softer in its proximal half. This softness provides a snug fit while sitting and standing and is particularly appreciated for comfort and cosmesis. It provides free hip motion while the long lever of the stump permits a more natural and less energy consuming prosthetic gait.

Knee joint

Every prosthetic knee joint designed for knee disarticulation can be combined with this socket. The type of prosthetic knee depends on the patients. In active and younger patients, a knee with hydraulic swing phase control is preferred. However, these devices are too heavy for geriatric patients where a joint with voluntary locking might be desirable.

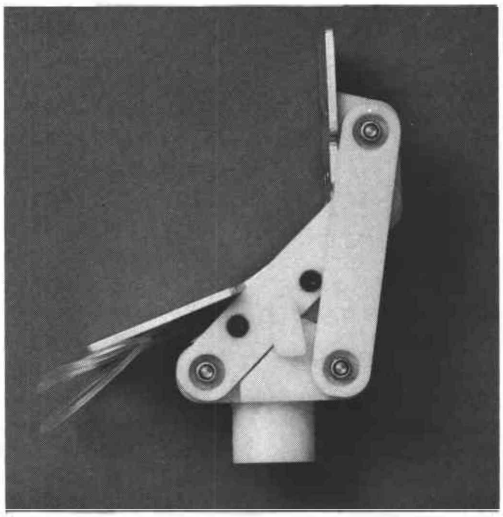

Fig. 4. Ultra lightweight four-bar knee with voluntary locking mechanism for geriatric patients.

For geriatric patients, an Otto Bock 3K9 geriatric knee was modified by dividing the axis in two halves thus saving length. Combined with a SACH-foot, this artificial limb has a total weight of less than 2,000 g. This solution however still causes an extra width of 10–15 mm. which may be partially or even entirely eliminated later because the soft tissues of the stump will shrink considerably.

In order to reduce the volume of the prosthetic knee without adding extra weight, a knee made from polyethylene (Fig. 4) for geriatric patients has recently been developed with excellent preliminary results.

Socket maintenance

Doffing and donning of the socket can be done by the patient while sitting and without physical effort. The patient first covers his stump with a nylon stocking. Some patients prefer to add a second stocking made from nylon or wool. The patient then puts on the inner liner which again is covered with another nylon stocking. The bulbous stump has now been transformed into a conic one which enters the prosthesis easily. The two sockets might be marked with dots to permit easy identification on the front side in order to avoid incongruence of the two liners in the transverse plane.

Cleaning of the inner liner is possible in the washing machine at low temperature; the outer socket is easy to clean with soap and water.

The cosmetic aspect of the TK socket is superior to AK sockets. In mature stumps, there is no more extra width and length which permits the patient also to wear snug pants. To obtain a maximum of cosmesis, the atrophy of the pelvi-trochanteric muscles might be compensated by an extra pad made from Plastazote (Fig. 5).

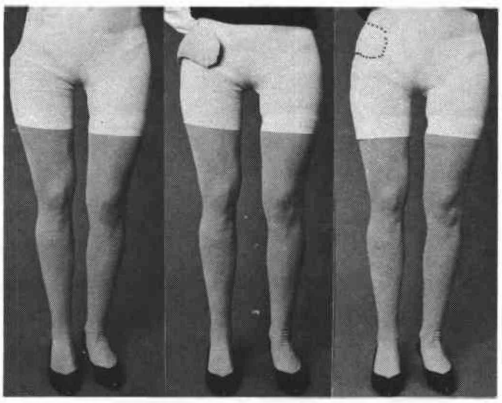

Fig. 5. For better cosmetic results, a pad made from Plastazote compensates the silhouette of the pelvis.

FURTHER READING

BAUMGARTNER, R. F. (1979). Knee disarticulation versus above-knee amputation. *Prosthet. Orthot. Int.* **3,** 15–19.

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