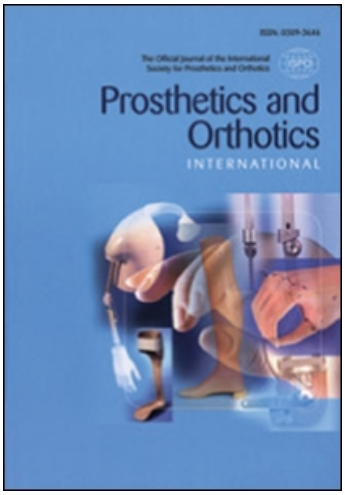

Prosthetics and Orthotics International
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t714595820

Technical note: A new trim line concept for trans-tibial amputation prosthetic sockets

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To cite this Article Söderberg, B.(2002) 'Technical note: A new trim line concept for trans-tibial amputation prosthetic sockets', Prosthetics and Orthotics International, 26: 2, 159 — 162
To link to this Article: DOI: 10.1080/03093640208726639
URL: http://dx.doi.org/10.1080/03093640208726639

Prosthetics and Orthotics International, 2002, 26, 159–162

Technical note

A new trim line concept for trans-tibial amputation prosthetic sockets

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Introduction

Proximal trim lines for trans-tibial prosthetic sockets have traditionally been trimmed according to the mode of suspension to the limb. The supracondylar suspension, which retains the prosthetic socket to the limb by gripping above the femoral condyles, has a more proximal trim line compared to the more distal trim line used for a suspension with a patellar-tendon-bearing strap or a thigh corset.

In more modern trans-tibial sockets other modes of suspension are used. A distal pin or coupling suspension used together with a roll-on silicone socket was introduced by Össur Kristinsson in 1987.

Carl Caspers introduced in 1991 a true total contact socket by using polyurethane with flow characteristics as an interface between the stump and the hard prosthetic socket. As a suspension mode for this socket an airtight sleeve was used with an expulsion valve fitted in the hard socket. This created a vacuum suspension (Board, Street and Caspers, 2001). This technique has partially been used earlier but not in connection with an expulsion valve. The technique, using an expulsion valve, should only be used together with a true total contact socket.

The new improved suspensions open possibilities for the re-design of the proximal trim line. For 5 years the author has used a new trim line which provides better "freedom" for activities, maximum sitting comfort, and better cosmesis. It also improves the durability if a vacuum sleeve is used.

This article describes the theory behind the new trim line and studies made on 45 patients in Sweden and France.

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Method

The four pre-requisites for a socket to create a good "fit" between the stump and the prosthesis are:

1. The correct socket volume for weight-bearing purposes.
2. The correct socket shape in order to reduce the movement between the skeleton and the socket and simultaneously to distribute

Fig. 1. New proximal trim lines drawn on a transparent check socket.

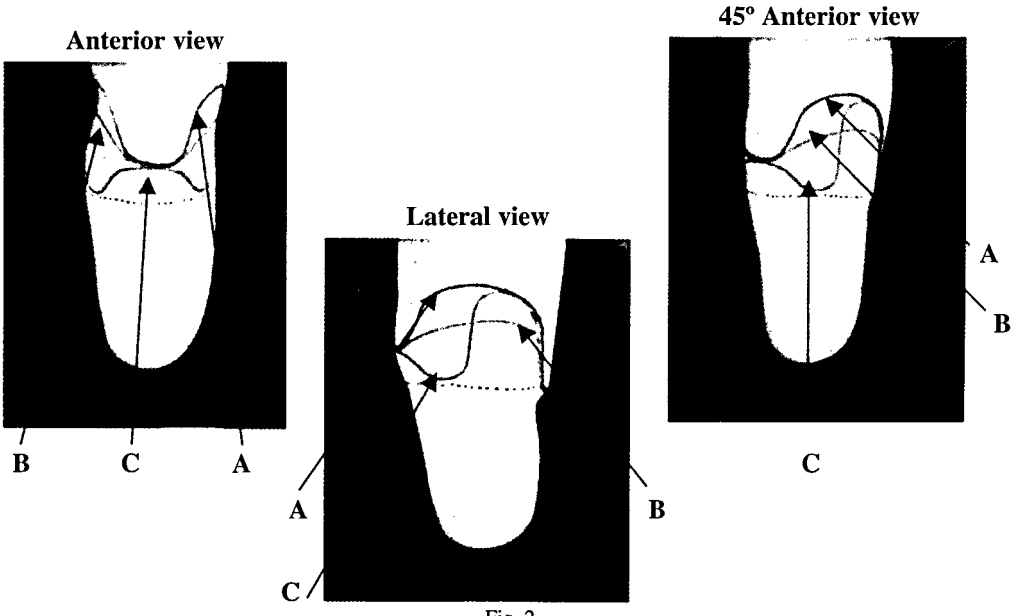


Fig. 2.

pressure according to skin tolerance. The shape is important to improve the control of the prosthesis.

3. An optimal suspension to reduce the piston action and improve proprioception. The correct position at heel strike must correlate to the position of knee flexion. (Lilja *et al.*, 1993).
4. A closed chamber technique in appropriate cases for improved socket atmosphere.

All four factors are closely linked together.

The traditional PTB concept (Radcliffe and Foort, 1961) does not address all these four factors. many authors have written about suspension, shape and total contact sockets, but very little is written about the interrelationship between the 4 pre-requisistes. The newer technique for socket also changes the theory of the proximal trim line.

Figure 2 shows the trim lines for supra-condylar suspension (A), the trim line for the PTB socket with cuff-strap suspension (B), and the new S trim line for vacuum sleeve suspension or alternatively distal end suspension like the pin suspension (C).

The theory of the suggested trim line is to:

A. create stability for socket-/stump rotation through the high posterior trim line;
B. improve comfort in flexion by allowing the femoral condyles to move out of the socket when sitting or bicycling;
C. distribute and reduce the resultant forces in the latter part of the stance by cutting the anterior trim line just under the apex of the patella;
D. achieve some mediolateral stability;
E. cut away unnecessary areas in the hard socket to improve the cosmesis both in standing and sitting;
F. create room for the medial and lateral hamstring tendons to improve comfort during muscle contraction during flexion;

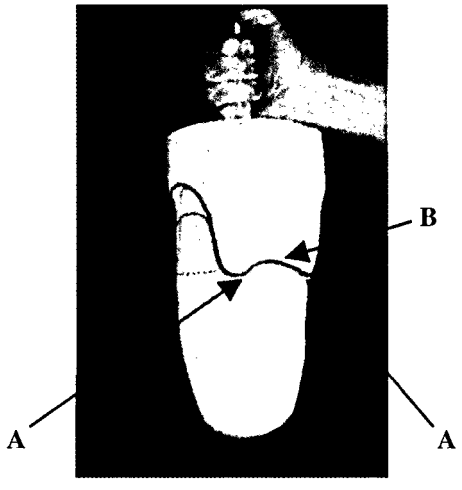


Fig. 3. Posterior trim lines should be cut as high as possible, still allowing sitting comfort (B).

G. enclose as much as possible of the stump in the socket to achieve increased anteroposterior stability.

The proximal posterior trim line is determined by the prominence and insertion of the hamstring tendons at knee flexion against resistance (A in Fig. 3). This posterior trim line is becoming even more important in vacuum sockets and sockets with distal suspension, which do not allow the stump to come out of the socket and lift up from the bottom during knee flexion.

The medial and lateral trim line is cut at the level of the height of the thigh when sitting down. During standing it should enclose the epicondyles but during sitting it should free the epicondyles anteriorly (Fig. 4).

The femur moves forward relative to the tibial plateau at 90° knee flexion. Additionally there is an external rotation of the tibia relative to the femoral condyles.

With this trim line the widest part of the knee moves out of the socket reducing pressure and improving "freedom" e.g. when cycling and sitting. With the traditional trim lines when the femoral epicondyles are not allowed to move out of the triangular shape, the socket is pushed forward and downwards.

Patients

Thirty (30) men and 15 women with mean age of 64 years (18-81), were fitted with the S trim line (C in Fig. 2). All subjects previously used total contact socket and vacuum sleeves with a traditional PTB trim line (B in Fig. 2). The patients were offered a change to the new trim line when they came for a change of the hard socket. None of the patients had mentioned complaints about the previous trim line.

Results

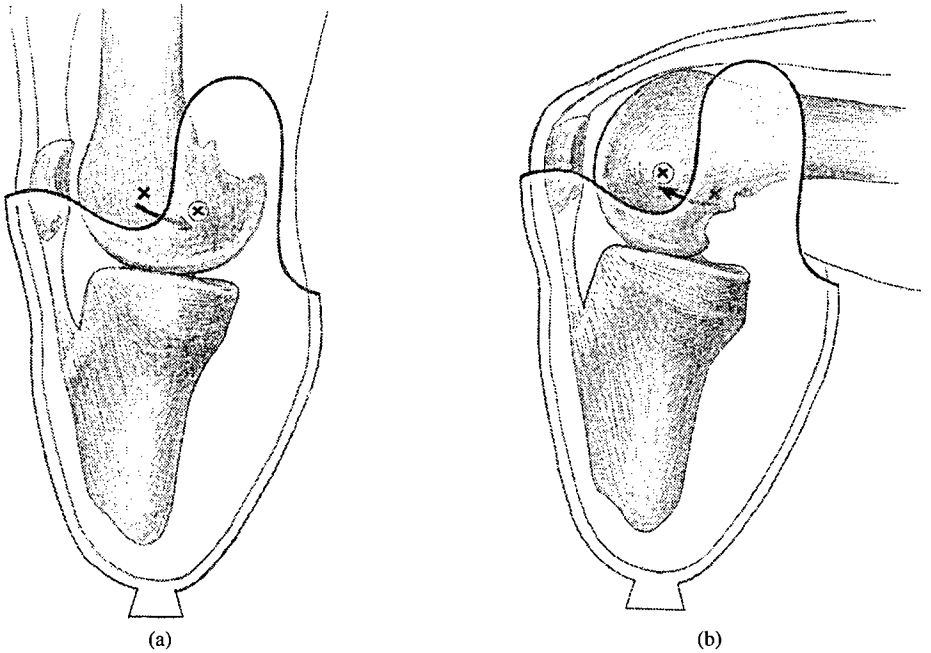
At follow-up at 2-3 months 42 of 45 patients were evaluated.

Thirty (30) patients reported a sensation of increased freedom and better sitting comfort, while 7 reported no difference, and 5 had to be changed back due to a tendency of hyperextension, and a feeling of instability probably due to a short stump.

A more appealing cosmetic look was noticed in all cases.

Discussion

From a straight knee to 90° flexion the epicondyles move anteriorly in relation to the tibia due to the sliding effect between the femoral condyles against the tibial plateau. This



(a) (b)

Fig. 4. Position of epicondyles (a) standing and (b) sitting.

means that in a socket with traditional trim lines (PTB, KBM) the epicondyles will push the socket anteriorly and a firm pressure sensation over the epicondyles will occur at 90° flexion or more.

With the new trim line the epicondyles are allowed to come out of the socket at flexion, providing more comfort when sitting.

One can also expect the airtight sleeve to last longer due to less friction over the proximal trim edge during sitting.

It seems that patients with short stumps, less than 10cm, need higher trim lines in order to prevent hyperextension of the knee. These cases are not suitable for the S trim line.

Acknowledgement

Special thanks to all amputees who consistently encouraged me to try new ideas and suffered the many different types of trials – good or bad.

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