Checkout Procedures for Below-Knee and for Above-Knee Artificial Limbs

By MARSHALL A. GRAHAM, M.S. and HERBERT E. KRAMER

Editor's Note: These two articles on checkout procedures originally appeared in the *Journal of the Association for Physical and Mental Rehabilitation*, 1956, volume 10, pages 89-93, 121-129, 135, and are reprinted by permission. In answer to our request, Henry C. Feller, C.P., Vice President of the J. E. Hanger Co., Washington, D. C., commented as follows on the outlines:

"The outlines are comprehensive and amply cover the functions that should be checked for a properly adjusted prosthesis. No doubt a test of the specific suggestions will be necessary and experience over a period of time will disclose any required modifications.

"This or a similar checkout procedure is necessary, however, and will be of inestimable benefit to all concerned, by co-ordinating the efforts of the members of the team and others concerned, in attaining the objective of the clinic team, a satisfactorily functioning and cosmetic prosthetic appliance."

PART I.

A Checkout Procedure for Below-Knee Artificial Limbs

There has been a growing trend in recent years to utilize the services of amputation clinics in the rehabilitation of amputees. These clinics, whose personnel include physicians, therapists, and prosthetists, have responsibility for the physical and prosthetic rehabilitation of the patient. Their responsibilities do not end with the prescription of a prosthesis, but include an evaluation of the adequacy of the prosthesis and training before the patient proceeds to subsequent phases of the rehabilitation program. It is known that an inadequate limb can result in insurmountable training problems and can hinder the physical, emotional, and vocational adjustment of the amputee.

Recently, as part of a nationwide research and educational program in upper extremity prosthetics, a checkout procedure for artificial arms was devised. The emphasis in prosthetic education has shifted from the upper extremities to the lower extremities. New York University and the University of California in cooperation with the Veterans Administration are developing lower extremities courses coordinated by the Prosthetic Research Board of the National Research Council. These courses for physicians, prosthetists and therapists, in addition to teaching fabrication, prescription, and training will include techniques of evaluation of lower extremity prostheses.

The major portion of the upper extremity procedure consisted of a check list of questions concerned with minimally acceptable prosthetic standards. If all the questions were answerable in the affirmative, the prosthesis was considered to be acceptable. Any questions answered in the negative immediately pointed up a deficiency in the prosthesis.

THE AUTHORS

Marshall A. Graham is an alumnus of the City College of New York and Springfield College, Springfield, Massachusetts, where he received the B.S. and M.S. Degrees with a major in physical education techniques applied to rehabilitation. He is now a doctoral candidate in this field at New York University. After working as a corrective therapist at the V. A. Hospital in Northport, Long Island, Mr. Graham joined the staff of the Prosthetics Devices Study of New York University.

A major concern during the six and one-half years with the Prosthetic Devices Study has been the physical aspects of amputation and prosthetic use, which culminated in the development, with Mr. Kramer, of the two articles on checkout procedures for below-knee and above-knee prostheses. He has also been a prosthetic consultant since 1953 to the Association for Physical and Mental Rehabilitation. Since September 1956 Mr. Graham has been employed as a Project Director with Space Utilization Analysis, Inc.

Herbert E. Kramer suffered an above knee amputation as a result of action with the infantry in Germany during World War II. Following separation from the Army he worked for the Veterans Administration's Prosthetic Center in New York for several years, training in the prosthetic field. He joined the Staff of New York University's Prosthetic Devices Study in 1947. Mr. Kramer has been specializing in gait and performance analysis, prosthetic evaluation and amputee training. In addition he himself has always been active in wearing and testing the latest experimental devices for above knee amputees. Other activities have included lecturing and demonstrating extensively to various medical meetings and other numerous organizations. In 1948 he was awarded the Patriotic Civilian Service Certificate from the Department of the Army "for furthering the program of research and development in artificial limbs." Recently his interest has once again brought his endeavor into the field of limb fitting.

In view of the success of the upper extremity checkout as an integral part of clinic procedure and as a result of many requests from physicians and therapists throughout the country, the authors have attempted to develop a check list by which the adequacy of a below-knee prosthesis can be determined. This check list pertains primarily to a conventional below-knee prosthesis as presented in Fig. 1. Although many variations are found, a conventional below-knee artificial limb is usually comprised of a wooden foot with toe-break; an ankle with provision for dorsi and plantar flexion (although some also make provision for inversion and eversion); a wood, metal, fiber or plastic shank; a carved wood, metal or molded leather or plastic socket; metal side braces with single axis knee joints; and a leather thigh corset. In addition, many below-knee amputees wear a waist belt with a fork strap attached to the shank, as an aid to retaining the limb on the stump, and a leather check lacer to control the knee joints in extension.

Fig. 1

Legend

A. Foot

B. Toe-break

C. Ankle joint and bushing

D. Front ankle bumper rubber or felt; acts as dorsiflexion stop)

E. Rear ankle bumper (rubber; for plantar flexion)

F. Anterior ankle articulation space (leather covered)

G. Posterior ankle articulation space (leather covered)

H. Shank (shin)

I. Air vent of shank

J. Fork strap

K. Check lacer

L. Knee joint

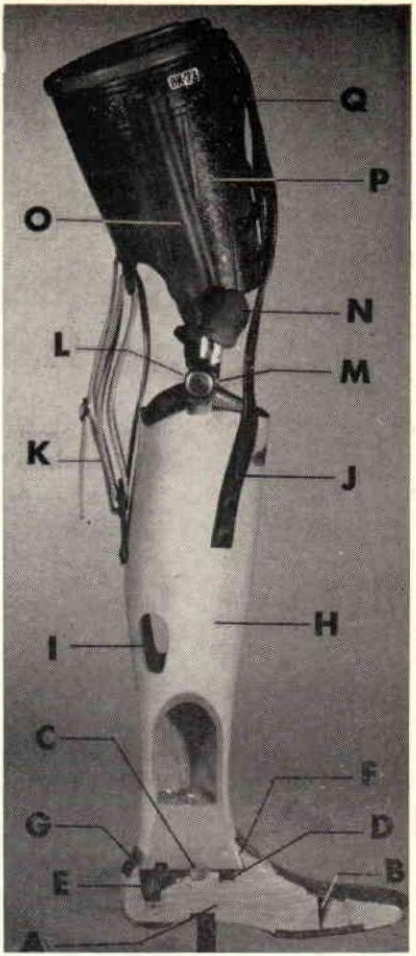
M. Knee joint extension stop

N. Knee joint cover

O. Thigh brace (leather covered)

P. Thigh corset (leather)

Q. Attachment strap or fork strap to waist belt



In this article, each italicized question represents a point to be checked by the clinic group. A brief discussion follows the question with occasional hints for correction of a subpar condition. A work sheet for clinic use can be easily drawn from the information contained in this article, supplemented by the reader's experience. A suggested form for the work sheet has a short underlined space preceding each numbered question, so that a check ($\surd$) or a "no" may be inserted as each item is covered at the clinic. The remedy for items that prove to have shortcomings may be obvious, in which case extensive discussion by the clinic group is unnecessary. It is the opinion of the authors that a checkout procedure such as this can facilitate the clinic functions by methodically emphasizing the most important factors in the prosthesis.

The reader should be cognizant of the fact that this article concerns itself solely with the determination of prosthetic adequacy. The entire area of functional adequacy of the amputee with this prosthesis as a concomitant of training and practice, is deserving of special treatment and is not covered in this article.

The check list which follows has been divided into four areas considered to be of major importance. The first area, quality control, is concerned with examination of the prosthesis before it is worn by the patient. The second area is concerned with the prosthesis worn by the amputee while standing. The third area is concerned with the posthesis worn by the amputee while sitting. The fourth and last area is related to the prosthesis worn by the amputee while walking. Any shortcomings of the prosthesis should be corrected and the limb rechecked by the clinic prior to the start of training.

A. Quality Control

1. *Is the color of the leg satisfactory and homogeneous?*

2. *Has the inside socket surface been completely and smoothly finished, and has a wood sealer been applied to the entire surface?*

In a wood socket, a wood sealer will prevent perspiration from the stump from penetrating the wood causing rough spots, rising of the grain, or cracking of the socket, any of which can cause stump irritation. A good finish will permit adequate hygienic care by allowing residual perspiration to be removed easily from the socket surface.

3. *Has the socket rim been adequately flared and all sharp edges smoothed?*

A sharp inside edge of the socket rim can cause discomfort and even laceration of the skin, especially in the case of obese amputees whose skin folds may overlap the socket.

4. *Is there a protective cover over the medial and lateral knee joint heads to prevent catching or tearing of trousers?*

This has been a continuing problem for below-knee amputees. Leather or plastic caps are available for placement over the joint heads.

5. *Do the knee joints articulate smoothly without resistance or excessive play?*

Excessive resistance will cause undue wear on the joint, shortening the maintenance-free period of wear. It will also force the amputee to exert more stump effort to extend the knee, resulting in more rapid fatigue. A loose joint can damage the bearings or, as a result of undue strain, cause a cracked joint. Rough action of the joints may be an indication of cracked or worn ball bearings, dirt, or lack of lubrication. Very often, noise will be associated with these conditions.

6. *Do both side braces come into contact with the knee extension stops simultaneously?*

Uneven contact of the knee extension stops will cause internal or external rotation of the prosthesis each time the knee reaches full extension in addition to causing uneven strain on the joints.

If a check lacer is worn, uneven setting of the joints may at first be overlooked. Usually a check lacer is used to prevent the clicking noise that occurs as the prosthetic knee reaches full extension. However, as the leather stretches, contact occurs at the knee stops and the deleterious effect of improperly set knee joints will become apparent. (Note: it has been the experience of the authors that check lacers can be eliminated in many below-knee prostheses. Generally, a lacer should be included on artificial limbs only for patients with short stumps and/or with knee instability due to weak

ligamentous structures. For other patients, elimination of a joint click can be accomplished by filing the knee extension stops and/or by the amputee resuming control of his knee so as to limit extension before the joint stops make contact.)

7. *Does the distance between the medial and lateral thigh braces remain constant during full flexion and extension?*

Inconsistent spacing between the thigh portion of the side bars during flexion and extension is an indication of misalignment of the knee joint heads. The joint heads should be perpendicular to an imaginary line through their centers and parallel to the line of progression of the prosthetic swing. Improper joint alignment will tend to distort the thigh corset and will influence the prosthetic swing while walking. It can contribute also to uneven wear of the knee joints and breakage of the thigh portion of the side bars.

8. *Is the brace and corset approximately 1 inch higher on the lateral side than on the medial side?*

The higher lateral shaping of the thigh corset will provide a better support for the muscles of the hip (which control movements of the femur) to work against, providing lateral stability.

The anatomical structure of the femur causes the body weight to lean laterally during the stance phase. This becomes exaggerated in amputees with the loss of muscular control at the base of support (foot and ankle).

9. *Has the thigh corset been finished in a workmanlike manner, i.e. lined, coated for resistance to perspiration, and sewn and riveted neatly?*

10. *Is there adequate clearance at the ankle articulation to prevent rubbing of parts or catching of socks?*

Too little clearance will cause rubbing of the inside surface of the foot on the ankle block which will cause noise. Too much clearance will allow sock material to catch, causing tearing and/or restriction of ankle movement.

11. *Has the artificial foot been properly upholstered and fitted to the shoe?*

Neat upholstery, with no "sharp" seams will do much to prevent tearing of socks. In addition, if the foot is too small, slippage of the shoe can cause tearing of socks. There also will be a tendency for the heel of the shoe to scuff the ground during the prosthetic swing phase.

12. *If used, do the fork strap and/or check strap have sufficient adjustment range? (Check length and holes on straps.)*

B. Standing

1. *Is the amputee secure while standing on the prosthesis with good posture and with heels touching?*

The amputee should feel that the prosthesis will remain directly under him while he is standing with his weight evenly distributed on both feet. If he feels that he is being forced backward, the prosthetic ankle may be set in too much plantar flexion. If he seems to be thrown forward and there is a tendency for the knee on the prosthetic side to buckle, the ankle may be set in too much dorsiflexion. If his weight is on the outside of the foot, the ankle is set in too much inversion; if his weight is on the inside of the foot, the ankle is in too much eversion.

2. *Is the amputee comfortable while standing on the prosthesis with good posture and with heels touching?*

Special attention should be directed to excessive pressure in such common areas of socket discomfort as:

a) posterior and distal to the head of the fibula
b) tibial tuberosity
c) anterior, distal tibia
d) anterior rim of the socket (in the area of the patellar ligament)

In addition, the amputee should not experience a choking sensation about the distal portion of the stump.

3. *Is the artificial leg the correct length?*

Incorrect length of the prosthesis can be determined by visual examination of the anterior-superior iliac spines or the superior iliac crests. The usual method of this examination is for the examiner to place his thumbs on the spinous processes or to place the hands on the crests of the illium, and by sight, judge whether or not they are level.

If the height is not correct, the use of prepared flat wooden slabs of varying thicknesses is helpful in determining the amount of correction necessary to attain the correct prosthetic length.

4. *Is the anterior rim of the socket properly contoured to allow medial and lateral movements of the patella?*

A narrow or high anterior rim of the socket that restricts lateral movement of the patella will generally force the patella upward causing the patellar ligament to be stretched. The amputee will experience discomfort because of jarring pressures on the patellar ligament at heel contact.

5. *Does the posterior rim of the socket extend high enough to prevent the formation of popliteal flesh roll?*

Experience has shown that keeping the posterior wall of the socket high enough to encase the flesh of the distal popliteal region reduces the tendency toward formation of a fleshy roll. A popliteal flesh roll can present a difficult fitting problem and restrict knee flexion.

6. *Do the side braces conform closely to the contour of the knee and thigh?*

Well-contoured side bars that provide a gripping action (without undue pressure) in the supracondylar region of the thigh will minimize the piston action of the socket on the stump, provide some lateral stability, and result in a more cosmetically acceptable prosthesis.

7. *Does the thigh corset fit snugly, with adequate adjustment for increasing the corset tension?*

There should be an opening of approximately 1 to 1½ inches between the corset borders. The adjustability of the thigh corset is particularly important for patients whose body weights fluctuate, and for recent amputees where considerable atrophy of the thigh may be anticipated. A thigh corset that cannot be tightened will become loose with thigh atrophy, disturbing the customary weight distribution between the corset and socket.

8. *Is the general shape of the prosthesis cosmetically acceptable?*

To be cosmetically acceptable, a below-knee prosthesis should approximate the shape and size of the non-amputated shank, ankle, and foot.

C. Sitting

1. *Is the amputee comfortable while sitting?*

This question is of a general nature. The various comfort factors are specifically covered in questions 2 to 6.

2. *Can the amputee sit with a minimum of 90 degree flexion and with his prosthetic foot flat on the floor?*

It should be possible for an amputee to sit comfortably in restricted areas, such as motion picture theatres and buses. In addition, restriction of knee flexion can cause the amputee's prosthetic foot to extend before him in a cosmetically unacceptable manner. There is also the danger of others tripping over an extended foot.

3. *Has the socket been properly shaped to prevent crowding in the hamstring and popliteal areas?*

Symptoms of improper socket contour are tingling and numbness of the stump and/or pressure of the socket rim on the medial (semimembranosus and semitendinosus) or lateral (biceps femoris) distal tendons. If such symptoms become evident, relief is usually indicated at the medial and/or lateral aspects of the posterior socket rim. In addition, socket pressure in the popliteal region indicates that the apex of the posterior socket rim is too high.

4. *Has the corset been properly shaped to prevent crowding in the hamstring and popliteal areas?*

An improperly shaped posterior distal thigh corset will cause bunching and irritation of flesh in the upper portion of the popliteal area. The distal corset should have an ox-bow shape with a cut-out for the ligaments high enough to prevent restriction of their normal function.

5. *Does the stump remain firmly situated in the socket while the amputee is sitting?*

The stump should not pull out of the socket or away from the anterior socket wall when the amputee is seated with knees flexed to about 90 degrees.

If the stump tends to pull out of the socket, it is an indication that the knee joints are placed higher than knee center and/or the posterior rim of the socket is too high.

If the stump tends to pull away from the anterior wall of the socket (gapping), it is an indication that the knee joints have been placed too far posteriorly. This is often accompanied by excessive pressure at the anterior distal tibia.

6. *Are both knees reasonably level while the amputee is sitting?*

For the below-knee amputee, this is a function of the correct length of the shank of the prosthesis as well as the correct positioning of the prosthetic knee joints.

D. Walking

1. *Is the amputee comfortable while walking? (If not, specify areas of discomfort.)*

Special attention should be directed to certain common areas of discomfort and irritation (see question 2 under the heading, Standing):

a) posterior and distal to the head of the fibula
b) tibial tuberosity
c) anterior, distal tibia
d) anterior rim of the socket (in the area of the subpatellar ligament)

The authors believe that these areas are worthy of emphasis since discomfort will become most evident when walking. The amputee's comments should be related to a careful examination of the stump at the conclusion of the walking phase of the checkout procedure.

2. *Is the amputee secure while walking?*

The amputee should feel that the prosthesis remains directly under him during stance phase with little or no tendency to shift his body weight laterally or medially. Lateral instability, usually associated with a shifting of the entire prosthesis laterally as full weight is taken on the artificial limb, may be corrected by increasing the amount of valgus (knock) of the prosthesis. This is accomplished by bending the upper portion of the side braces. Displacing the prosthetic foot laterally on the shank is another way of widening the support base. The latter method, although more difficult, will not influence the positioning of the stump within the socket, whereas bending of the side bars may result in stump discomfort. Conversely, medial instability (which is less prevalent) is corrected by increasing the varus (bow) of the prosthesis, or displacing the foot medially.

Anterior-posterior stability is primarily a function of the foot-shank relationship. General prosthetic practice has aligned the foot on the shank at an angle of slightly less than 90 degrees of dorsiflexion. Excessive dorsiflexion will cause the amputee to flex his knee prematurely while walking, resulting in a "dipping" gait and giving the impression of too short a prosthesis. Excessive plantar flexion will cause difficulty in transferring weight over the ball of the foot, resulting in an irregular gait and giving the impression of too long a prosthesis.

3. *Does the prosthesis swing in a straight line of progression?*

The three major variations of the swing of a prosthesis in the sagittal plane are:

a) medial whip
b) lateral whip
c) circumduction

A medial whip is characterized by a movement of the heel of the prosthetic foot medially and a rotation of the knee laterally, which can best be observed immediately after toe-off. The foot then rotates back to its usual position either during the remainder of the swing phase (causing a "fish tail" effect), or as the heel of the prosthesis is contacting the ground with the toe rotating medially. A medial whip can usually be corrected by moving the upper portion of the medial side brace posteriorly on the thigh lacer.

A lateral whip is the reverse of a medial whip, with the heel of the foot moving laterally and the knee rotating medially immediately after toe-off of the prosthesis. A lateral whip can usually be corrected by moving the upper portion of the medial side brace anteriorly on the thigh lacer.

Circumduction is a movement of the prosthesis in a lateral arc from a straight line of progression. Circumduction is seldom seen with below-knee amputees, but if present can be caused by the amputee walking with little or no knee flexion and so moving his prosthesis outward to insure that the foot clears the ground.

4. *Is the toe-out of the prosthetic foot the same as that of the normal foot?*

5. *Does the amputee walk with a reasonably narrow base of support?*

In evaluating this item, each amputee must be considered as an individual. The length of his stump and his general body type must be taken into con-

sideration. It is to be expected, for instance, that an obese person will walk with greater natural abduction than one who is thin or muscular.

In order to increase lateral stability, it has been the practice to fit very short below-knee stumps with a prosthesis set in exaggerated valgus (the prosthetic foot outset), which produces an effect of abduction.

There is no reason why the average below-knee amputee with no special physical or prosthetic complication cannot walk with his base of support as narrow as that of the nonamputee. This is usually between ½ and 2 inches.

6. *While walking, is the plantar surface of the prosthetic foot flat on the ground during stance phase?*

Observation of the attitude of the foot during the prosthetic stance phase will show whether the foot has been properly aligned on the shin. An everted or inverted foot will cause uneven wear of the sides of the sole of the shoe and may be the cause of lateral instability. Plantar and dorsiflexion have already been discussed (see question 2 under the heading *Walking*).

7. *Is the resistance of the ankle to plantar flexion properly set to prevent foot-slap or external rotation immediately after heel contact?*

If there is too little resistance (caused by too soft a rear ankle bumper) the prosthetic foot will strike the floor too rapidly after heel contact, causing a slapping noise. Too much resistance (caused by a rear ankle bumper that is too hard) will cause the prosthetic foot to delay striking the floor after heel contact. This will allow the natural rotation of the leg to externally rotate the prosthetic foot before it is flat on the floor. The delay of the sole of the foot in contacting the floor is readily observable as the amputee walks.

8. *Is the "piston action" between the stump and socket minimal during walking?*

An easy method for determining piston action between the stump and the socket is by observation of the action of the base of the patella as it moves away from and toward the anterior socket rim. A pencil mark on the stump sock can be most helpful in this observation. The motion noticed when the knee is flexed should be ignored. It is after the knee is extended and weight placed on the prosthesis that the amount of pumping can be most accurately determined. Displacement of one-half to three-quarter inch is not unusual. Obviously, it is desirable to have little piston action.

9. *Does the prosthesis function in a smooth, noise-free manner?*

Common areas and sources of noise are:

a) the ankle joint, which may require greasing
b) the space between the foot and ankle which may be inadequate and cause rubbing (a home remedy is to insert soap scrapings into the space)
c) the knee joints, which may require greasing
d) clicking of the knee joint extension stops, which is usually eliminated by the use of a check lacer or by filing the stops.

At the conclusion of the walking phase of the checkout procedure, the amputee's stump should be examined for any irritated or discolored areas, with particular attention directed to the common areas of discomfort previously described. Some indication of how weight is distributed over the stump can be obtained by the impression left by the stump sock on the skin.

This paper has attempted to delineate the areas considered by the authors to be of major importance in determining the prosthetic adequacy of a below-knee artificial limb.

PART II.

A Checkout Procedure for Above-Knee Artificial Limbs

By MARSHALL A. GRAHAM, M.S. and HERBERT E. KRAMER

In the preceding article the authors present a procedure for evaluating the adequacy of below-knee prostheses. The problems of above-knee amputees are more acute than are those of below-knee cases, primarily as a result of the greater functional anatomical loss due to the higher amputation site.

A conventional above-knee prosthesis usually consists of a wood foot with a toe-break (Fig. 1); an ankle with provision for dorsi and plantar flexion (although some also provide inversion and eversion); a wood, metal, fiber or plastic shank; a single or multiple axis knee (providing flexion and extension) (Fig 2); a carved wood, metal, molded leather, or plastic socket; and a pelvic belt with single or double axis hip joint (or an air valve, if a suction socket is used). Fig. 3 presents two conventional above-knee prostheses. One is fitted with a pelvic belt as the major means of suspension (No. 1), while the other utilizes the suction socket principle (No. 2). In addition, many above-knee amputees wear an extension aid in the form of a kick strap, hickory lever, wrap spring, coil spring, or compressible rubber bumpers to help in achieving knee extension while walking.

In past years there has been great emphasis placed on finding solutions to the problems of above-knee amputees. Because of this, an impressive array of literature is available concerning the fit, alignment, biomechanics, and training related to above-knee prostheses. However, to the writers' knowledge, there has been no comprehensive clinical procedure set forth by which th adequacy of an above-knee prosthesis could be determined. It is the purpose of this paper to present such a procedure.

As in the article dealing with below-knee prosthesis checkout, each italicized question represents a point to be checked by the clinic group. A brief discussion follows the question with occasional hints for correction of a substandard condition. A work sheet for clinic use can easily be drawn from the information contained in this article, supplemented by the reader's experience. A suggested form for the work sheet has a short underlined space preceding each numbered question, so that a check ($\surd$) or a "no" may be inserted as each item is covered at the clinic. The remedy for items that prove to have shortcomings may be obvious, in which case extensive discussion by the clinic group is unnecessary.

The check list which follows has been divided into four areas considered to be of major importance. The first area, quality control, is concerned with examination of the prosthesis before it is worn by the patient. The prosthesis is then examined as it is worn by the amputee while standing, sitting and walking. Any shortcomings of the prosthesis should be corrected and the limb rechecked by the clinic prior to the start of training, since it is known that an inadequate limb can result in insurmountable training problems and can hinder the physical, emotional, and vocational adjustment of the amputee.

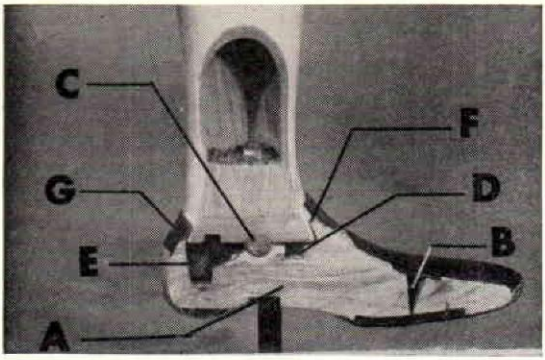


Fig. I—Legend: A. Foot, B. Toe-break, C. Ankle joint and bushing, D. Front ankle bumper (rubber or felt; acts as doriflexion stop), E. Rear ankle bumper (rubber; for plantar flexion), F. Anterior ankle articulation space (leather covered), G. Posterior ankle articulation space (leather covered).

A. Quality Control

(To be checked with the prosthesis off the patient.)

1. *Is the color of the leg satisfactory and homogeneous?*
2. *Has the inside socket surface been completely and smoothly finished, i.e. a wood sealer covering the entire surface?*

   In a wood socket, a sealer will prevent perspiration from the stump from penetrating the wood, causing rough spots, raising of the grain, or cracking of the socket, any of which can be the cause of stump irritation. A good finish will permit adequate hygienic care, allowing residual perspiration from the socket surface to be easily removed.
3. *Has the socket rim been adequately flared, and all sharp edges removed?*

   A sharp inside edge of the socket rim can cause discomfort and even laceration of the skin, especially in the case of obese amputees whose skin folds may overlap the socket rim.
4. *Is a back pad attached to the posterior socket wall?*

   When the amputee seats himself on a hard surface, a back pad attached to the posterior socket wall will help to:

   a. Reduce the wear on trousers.
   b. Muffle the sound of the socket contacting the hard chair surface.
5. *If a pelvic joint is used, does the joint articulate smoothly without resistance or excessive lateral play?*

   Excessive resistance will cause undue wear of the joint, shortening the maintenance-free period of use. It will also restrict hip motion, necessitating added effort by the amputee.

   A loose joint can cause noise and loss of prosthetic control (by lateral movement of the socket) or, as a result of undue strain can fracture the hip joint.

6. *Is there proper clearance between the anterior portion of the knee and shank during knee flexion and extension?*

Too little clearance will cause rubbing of the surfaces between the knee and the anterior-proximal shank, producing noise. Too much clearance will allow the trouser material to catch, resulting in tearing and/or a restriction of knee motion. Catching of the trouser is most likely to take place when rising from a sitting position or when walking into the wind.

7. *Is the knee extension stop padded?*

The knee extension stop should be padded with felt, rubber or other shock absorbent material. The padding will help muffle noise caused by contact between the knee stop and the socket, as well as to reduce the impact at full extension during walking.

8. *Can the prosthetic knee be flexed a minimum of* 120°?

When sitting, adequate knee flexion will permit positioning of the prosthetic foot well under the chair.

This knee flexion range is also important to allow the amputee to kneel comfortably, since limited knee flexion will cause the amputee to fall forward and can cause stump discomfort.

A quick method for determining if the prosthetic knee allows sufficient flexion is to place the prosthesis in a kneeling position on a flat surface. With the knee flexed to its maximum, the longitudinal axis of the socket should be posterior to a vertical line through the knee axis.

9. *Is the posterior-distal socket supported over the entire cut-out area of the shank during maximum knee flexion?*

This is particularly important when the amputee kneels. If the posterior-distal socket is not evenly supported over the entire shank cut-out area, there is a strong possibility that the posterior portion of the shank will splinter, crack or become deformed.

10. *Is there adequate clearance in the ankle articulation to prevent rubbing of parts or catching of socks?*

Too little clearance will cause rubbing of the inside surface of the foot on the ankle block, which may produce noise. Excessive clearance will allow the sock to catch, causing tearing and/or restriction of ankle movement.

11. *Has the artificial foot been properly upholstered and fitted to the shoe?*

Neat upholstery with no sharp protrusions or edges will do much to prevent tearing of socks.

If the foot is too small, slippage of the shoe can cause sock damage, or a tendency for the heel of the shoe to scuff the ground during the prosthetic swing phase. Naturally, if the foot is too large the amputee will find it difficult to change shoes or socks on his prosthesis.

12. *If a kick strap is used, is there adequate adjustment for increasing or decreasing tension?*

13. *In a suction socket, can the valve body be threaded easily in and out of the valve seat?*

It is important that the threads of the valve seat be free of glue or dirt, as improper seating of the valve body may cause loss of suction and/or "anti-social" noises.

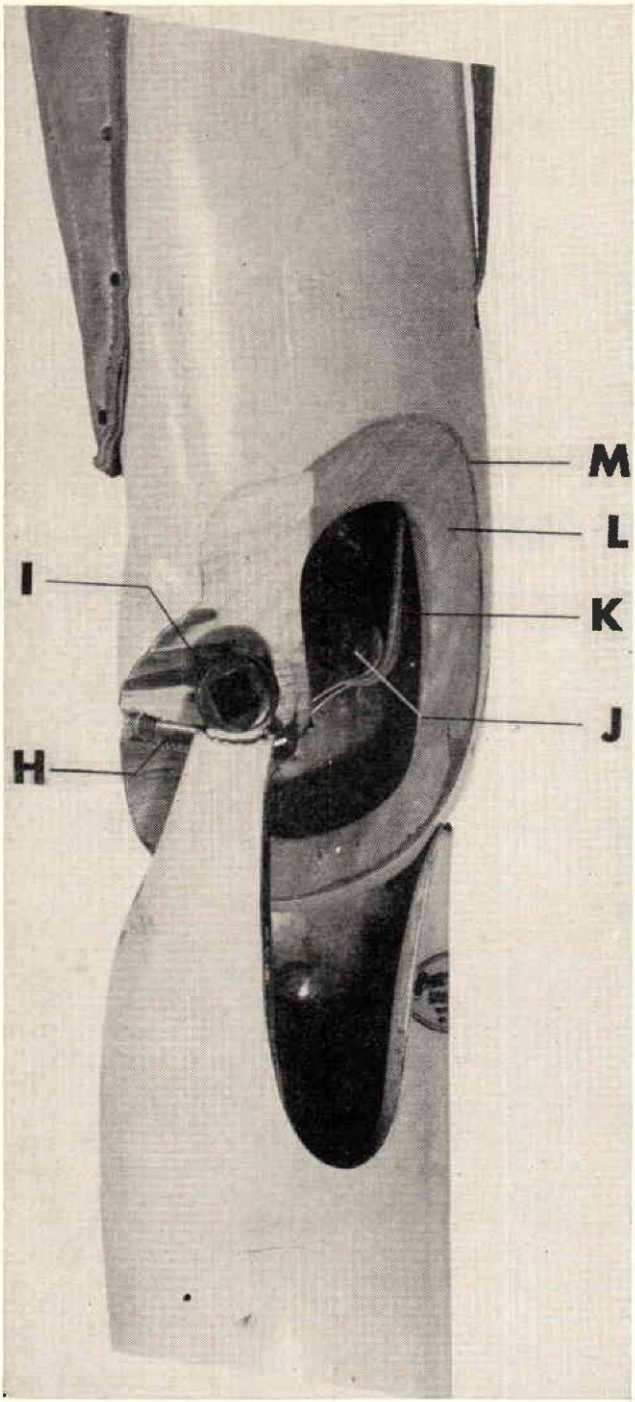


Fig. II—H. Knee friction adjustment screw, I. Knee bolt (single axis), J. Knee control roller, K. Knee control strap, L. Willow or Bass wood construction, M. Rawhide over wood (painted).

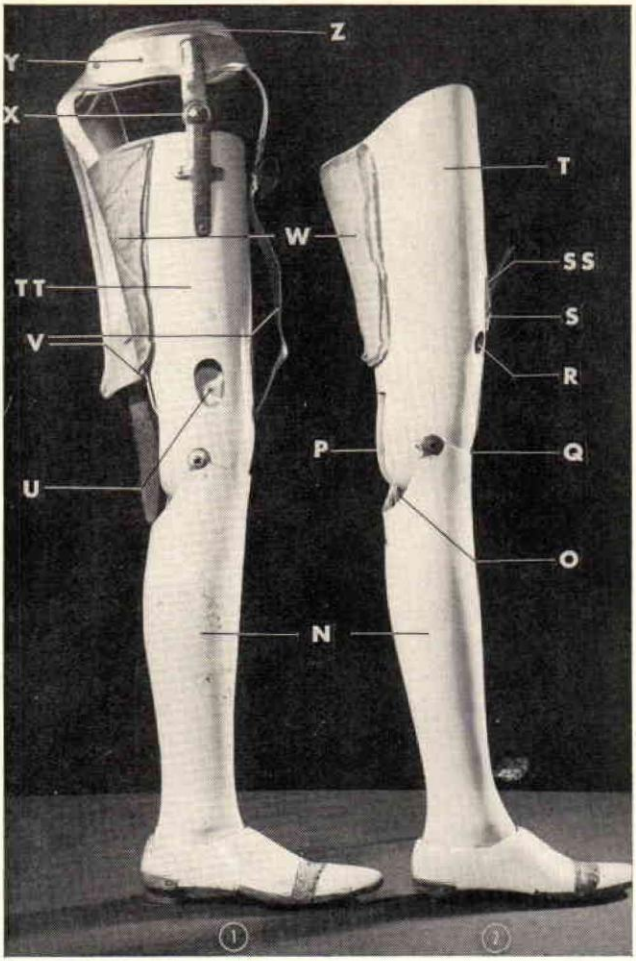


Fig. III

N. Shank (Shin)
O. Knee extension stop
P. Cut out of knee (permits knee flexion)
Q. Knee
R. Suction socket valve opening
S. Kick strap adjustment buckle
SS. Kick strap
T. Suction socket
TT. Conventional, pelvic belt socket
U. Air vent opening
V. Knee control strap
W. Back pad
X. Pelvic joint
Y. Pelvic band
Z. Pelvic belt

B. Standing
(prosthesis on)

1. *Is the amputee secure while standing with good posture and with heels together?*

When the amputee stands with good posture and heels together, there should be no tendency for the prosthetic knee to buckle. Although the stump is extended to the rear, pressure should not be necessary to maintain knee stability. As a further check, have the amputee balance momentarily on the prosthesis, with the sound foot off the ground, to be sure the prosthetic knee does not buckle. (The fact that the amputee cannot balance himself on the prosthesis for any appreciable time does not indicate a prosthetic shortcoming, but may be due to inadequate training.)

Increased knee stability for the amputee can be accomplished most expeditiously either by (a) increasing knee extension by adjusting the knee extension stop or (b) setting the foot in additional plantar flexion.

These adjustments should be made conservatively or they may create such problems as:

a. Hyper-extension of the prosthetic knee which can result in increased lumbar lordosis when the prosthesis is in stance phase. In addition, it will force the amputee to use greater stump effort to initiate knee flexion while walking, causing fatigue and/or poor appearance of gait (excessive rearward heel rise at toe-off).

b. Excessive plantar flexion of the ankle which may cause the amputee to complain of a sensation of walking "up a hill" as he transfers his weight over the ball of the prosthetic foot, resulting in the feeling that the prosthesis is too long. In order to compensate for this apparent increase in length the amputee may develop such poor walking habits as rising excessively on the ball of the normal foot during the swing phase of the prosthesis (vaulting) or walking with an abducted or circumducted gait.

If the two prosthetic adjustments mentioned above are not successful, it may be necessary to sever the socket from the knee block and set it more anterior to the knee axis. It is routine prosthetic practice to fit amputees with medium or short stumps with the knee bolt posterior to a reference line between the greater trochanter of the femur and the ankle axis. In contrast, a well-trained amputee with a longer, well-developed stump can tolerate the knee axis closer to the trochanteric-ankle axis line, as an amputee of this type can more readily control prosthetic knee flexion.

2. *Is the amputee comfortable while standing on the prosthesis with good posture and heels close together?*

The above-knee amputee bears weight primarily at the:

a. Ischial tuberosity

b. Gluteus maximus region

Weight-bearing is avoided as much as possible in the adductor, femoral triangle and ramus regions of the stump. Some weight is borne over a major portion of the remaining area of the stump, extending to approximately 1½ inches of the end. The distal stump should be relatively free of weight, since it is generally more sensitive in this area.

3. *Is the artificial leg the correct length?*

The adequacy of the length of the prosthesis can be determined by visual examination of the anterior-superior iliac spines. The usual procedure is for the examiner to place his thumbs on these spinous processes and by sight judge whether or not they are level.

If the height appears unsatisfactory, the use of prepared flat wooden slabs of varying thicknesses (⅛", ¼" and ½") is very helpful in determining the amount of alteration necessary to correct the length of the prosthesis.

4. *Is the anterior-medial area of the socket wall properly contoured to avoid excessive pressure in the femoral triangle region?*

Too tight a fit in the femoral triangle (Scarpa's triangle) region will usually cause an "aching sensation." Too low a fit in the femoral triangle will cause the development of a flesh roll which may present serious fitting problems.

The need for a properly contoured socket in this area is critical, since edema of the stump is often associated with restriction of the lymphatic and venous return, due to localized restriction in the femoral triangle as well as the distal regions of the stump.

5. *Is the medial socket wall the correct height to prevent (a) formation of an adductor flesh roll and (b) excessive pressure on the ramus of the pubis?*

A low medial wall may not initially cause the amputee any appreciable discomfort. However, with time, an adductor roll will develop which will not only hinder the amputee's gait (as he will tend to walk with the prosthesis in abduction to avoid friction and pressure) but will also cause fitting difficulties. It is felt that the medial wall should be no more than $\frac{1}{4}$ inch lower than the level of the ischial seat of the socket.

Ideally, the ramus should be located inside the medial socket wall which should be so shaped as to minimize pressure during weight-bearing.

6. *Is the ischial tuberosity properly situated on the ischial support of the socket?*

Present knowledge of above-knee prostheses indicates a quadrilaterally shaped socket with a definite flat portion on the posterior-medial rim, which becomes the major weight-bearing area of the socket (for placement of the ischial tuberosity of the pelvis). If the ischium should slip off this socket support area, the amputee will experience acute discomfort. Improper placement of the ischial tuberosity on the socket rim (tuberosity inside the socket) is an indication that the distance between the anterior and posterior socket walls is too great, providing insufficient counterpressure along the anterior socket wall for stabilizing the ischial tuberosity on its seat. This distance between the anterior and posterior socket walls represents a critical measurement of the amputee's stump (the distance between the adductor longus tendon and the ischial tuberosity). Present expert opinion is that the ischial tuberosity should be located one-half inch posterior to the inner surface of the rear wall and one inch from the inner medial socket wall. Therefore, the anterior-posterior dimensions of the inner socket walls should be one-half inch less than the adductor longus-ischial tuberosity measurement.

To determine whether the ischial tuberosity is properly positioned on the socket, have the amputee remove his weight from the prosthesis, place a finger (with the palm up) on the ischial tuberosity and allow the amputee to re-apply his weight to the socket. In cases where location of the ischial tuberosity is difficult (muscular and/or obese patients), it may be necessary to have the patient bend forward in order to properly locate the bony prominence and then have him straighten up as he re-applies weight to the prosthesis.

It is further suggested that the clinician mark the location of the ischial support on the socket before removing his finger. This mark will allow location of the ischial support with the prosthesis off the patient.

7. *Is the distal stump free of tension?*

To check the tension of the skin at the end of the stump, insert a finger through the valve opening of the suction socket or through the air vent opening of a conventional socket and palpate the stump while the amputee alternates his weight on and off the prosthesis. This procedure will also tell the relative position of the stump within the socket and give information about the pumping action taking place between the stump and socket.

Excessive tension on the distal stump will cause an uncomfortable pulling sensation that is often exaggerated when scar tissue is in this area.

8. *Is there adequate socket space distal to the stump while the amputee puts full weight on the prosthesis?*

   There should be approximately 2 inches of socket space distal to the stump to reduce the possibility of the end of the stump hitting the bottom of the socket during full weight-bearing or if the stump should slip too far into the socket.

   Limited clearance in the suction socket will mean too small an air space which may cause too great a fluctuation of positive and negative pressures during use. The recommended suction socket pressure in the past has been one to two pounds per square inch for both negative and positive pressures. However, this should not be a hard and fast rule. There have been reports of successful suction socket wearers with socket pressures as high as four to five pounds per square inch.

9. *On weight-bearing does the stump stay in contact with the lateral socket wall?*

   On weight-bearing the lateral stump should be in firm contact with the socket wall in order to afford maximum lateral support for the amputee. This can be determined best by asking the amputee if the lateral wall gives support without pain or discomfort.

   In the suction type socket, the lateral fit becomes more critical. There should be no gap between the lateral rim of the socket and the amputee's stump, as this will cause breakage of the suction seal allowing air to enter or escape from the socket with accompanying "anti-social noise."

10. *If a pelvic belt is used, does it accurately fit the contours of the body?*

    The pelvic belt should pass between the iliac crest and the greater trochanter and not exert excessive pressure on the anterior-superior iliac spine. A well fitting pelvic band and joint will do much to overcome excessive pumping action between the stump and socket while walking. Excessive pumping action can cause skin irritations of the stump and may force the amputee to walk with a gait characterized by vaulting, abduction or circumduction.

11. *If a pelvic belt with hip joint is used, is the head of the joint located on or anterior to the greater trochanter?*

    The pelvic joint should be attached to the socket on or slightly anterior to the greater trochanter and parallel to the line of progression for best function while walking and comfort while sitting. Pinching of the flesh in this area is not uncommon with an improperly located pelvic joint. (Also, see SITTING, questions 4 and 5).

12. *If a Silesian belt is used, are the attachments properly located?*

    The lateral attachment of the Silesian bandage should be at a point about ¼ inch posterior to the greater trochanter.

    The anterior attachment should be at or near a point formed by the intersection of:

    a. a horizontal line at the level of the ischial seat
    b. a vertical line down the middle of the socket

C. SITTING

1. *Can the amputee sit comfortably with his hip flexed to 90 degrees?*

   Particular attention should be directed to the anterior socket rim while the amputee is seated with the hip and knee flexed to 90 degrees.

With the suction socket, too high an anterior wall may push against the bony prominence of the pelvis, displacing the socket. There is usually no discomfort with too low an anterior wall of a suction socket, although this is conducive to the development of an anterior flesh roll.

With the pelvic belt leg, too high an anterior wall can cause pressure and pain where it strikes the pelvis and can restrict hip flexion. Too low an anterior rim may cause crowding and pinching of the flesh of the anterior proximal stump.

An additional check of the correct height of the anterior socket wall is to have the amputee bend forward and touch his feet while sitting.

2. *Is the prosthetic knee the correct height and length in proportion to the sound knee?*

The prosthetic knee presents an objectionable appearance if it extends beyond or is higher than the sound knee while the amputee is sitting. Either of these conditions indicates that the prosthetic knee axis does not coincide with the center of rotation of the sound knee.

If the prosthetic knee extends too far (knee center too low and socket too long) the prosthetic foot may not reach the floor. If the prosthetic knee is too high (knee center too high) the amputee may have difficulty when sitting at a desk or table or when driving a car.

An amputee with a long-above-knee stump (supra-condylar or Gritti-Stokes amputation) may require a prosthesis with a knee center that is lower than the sound knee in order to allow for fitting with a conventional above-knee prothesis. This is especially true of a suction socket, due to the need for an air space.

3. *Does the knee remain flexed while the amputee is seated?*

If an extension aid has too much tension, it will tend to extend the prosthetic knee when the foot is lifted from the floor. This condition is more prevalent with amputees who do not utilize knee friction.

4. *Can the amputee sit without the prosthesis internally or externally rotating?*

The outer posterior socket wall should be relatively flat, so that the posthetic shank remains vertical when in contact with a hard surface.

Another cause of medial or lateral rotation of the prosthesis while sitting is improper placement of the pelvic joint. If the joint head is placed too far anteriorly (and medially rotated to the line of progression) the thigh portion of the prosthesis will rotate internally and the shin will abduct. If the joint head is placed too far posteriorly, the thigh portion of the prosthesis will rotate externally and the shank will adduct. As previously mentioned, the recommended placement of the pelvic joint is on or slightly anterior to the greater trochanter.

5. *Does the prosthesis remain in good abduction-adduction alignment?*

While sitting, the amputee should be able to maintain comfortably the thigh portion of the prosthesis parallel to the thigh of his non-amputated limb.

Although adduction is not usually encountered, abduction of the thigh is quite common. The amputee may abduct the prosthesis to relieve pressure in the adductor or femoral triangle regions of the stump.

A second cause may be that the pelvic joint assembly does not closely follow the anatomical contours of the hip and thigh while sitting. There should not be a large gap between the joint and the body, and the joint assembly should not be in abduction in relation to the body parts. Pressure or gapping of the pelvic band can also cause abduction.

6. *Does the lateral wall remain in contact with the stump?*

Gapping at the lateral wall of the socket while the amputee sits is an indication that the socket fit or alignment is improper. The socket should fit snugly around the entire stump periphery. Gapping is usually associated with pressures at the lateral-distal and/or the medial-proximal stump and can often be attributed to poor shaping of the socket. In addition, there is a problem of air loss for the suction socket wearer.

7. *Is the ischial support area of the socket properly contoured to prevent stump discomfort?*

A sharp burning sensation in the ischial tuberosity area is an indication of insufficient relief for the hamstring muscle tendons as they are stretched over the ischial support region of the socket. The burning sensation is the result of pressure on the stretched tendons as well as friction. The usual procedure is to relieve the ischial support region within the socket by sloping the socket in this area or by channeling the socket to allow sufficient room for the tendons of the hamstring muscles. This burning sensation is usually noticed after several moments of sitting.

8. *With the suction socket, can the amputee reapply his weight after sitting without any disturbing "suction noises"?*

Ask the amputee to stand, putting his weight on the prosthesis. A flatulating noise occurring when weight is re-applied, is an indication that air has re-entered the socket (commonly at the lateral socket wall). A condition of this type can be very embarrassing to the wearer and if not corrected, may result in the rejection of the suction socket. A high, well-contoured socket fit across the lateral wall will prevent this type of noise.

D. Walking

1. *Is the amputee comfortable while walking? If not, specify areas of discomfort.*

Areas of discomfort of the stump, which may not be a problem while sitting or even standing, become acute while walking, due to the constantly changing distribution of weight in the socket.

Special attention should be directed to the following regions in which discomfort and irritation are commonly found:

a. Ischial tuberosity
b. Ramus of the pubis
c. Proximal adductor region
d. Femoral triangle (Scarpa's triangle)
e. Distal lateral region

Every effort should be made to provide the amputee with a comfortable socket, since his adaptability to training and his subsequent performance depends heavily upon being comfortable.

2. *Is the amputee secure while walking?*

Prosthetic instability of the above-knee amputee consists basically of two types: (a) buckling at the knee and (b) lateral instability.

(a) *Buckling at the knee* is the more dangerous of these two balance problems since inadvertent flexion of the prosthetic knee, occurring when the prosthesis is weight-bearing (stance phase) can

cause falling. Three common causes of an insecure prosthetic knee are:

(1.) Faulty anterior-posterior alignment of the knee. The center of rotation of the knee is too far anterior to a reference line between the greater trochanter and the prosthetic ankle axis (see question 1, STANDING).

(2.) Too hard a rear ankle bumper (plantar flexion bumper). Too hard a rear ankle bumper resists plantar flexion at the time of heel contact causing the forward momentum of the body to be applied to the knee resulting in a tendency to buckle. This can be overcome to some extent by excessive rearward stump pressure.

(3.) Excessive dorsi-flexion of the prosthetic ankle. General prosthetic practice is to align the foot on the shin at an angle of 90 degrees or slightly greater (plantar flexion). Excessive dorsi-flexion will place the knee axis too far anterior to the greater trochanter-ankle axis line, so that when the amputee transfers his weight to the prosthesis, the knee will tend to buckle.

If the prosthetic knee is unstable, the amputee may incorporate various compensatory movements in his gait pattern to overcome the difficulties he may be experiencing. The four most common observable compensatory movements are:

(a) forcefully flexing the prosthetic knee and then abruptly extending it with a whip-like motion

(b) overextending the prosthesis, deliberately taking a long prosthetic step and then exaggerating the hard impact at heel contact

(c) walking with a slow, halting gait and with "double knee action"; the prosthetic knee does not maintain full extension as the weight is transferred to the prosthesis after heel contact and the amputee re-extends the knee by forcing the socket backwards with his stump

(d) lordosis—the amputee uses extensor muscles of the back as a substitute for weak hip extensors to help maintain knee extension.

(b) *Lateral instability*—The amputee should feel that the prosthesis remains directly under him during stance phase with little or no tendency to shift his body weight laterally. Lateral instability is usually associated with a shifting of the entire prosthesis laterally as full weight is taken on the artificial limb. The two basic causes of this inncorrect instability are improper medial-lateral alignment of the prosthesis and inadequate training.

Improper alignment may be corrected by increasing the width of the walking base. The suggested way of doing this is to displace the knee-shank-foot of the prosthesis laterally in relation to the socket. This procedure widens the base of support without influencing the position of the stump within the socket.

A second cause of lateral instability is inadequate training. An amputee should be trained in balancing, so that he is able to utilize the hip abductors on the amputated side for maintaining a stable position.

As in knee stability, the amputee may compensate in his gait pattern for the feeling of lateral insecurity by walking with an abducted gait or with considerable lateral bending of the trunk over the prosthesis.

3. *Does the amputee walk with a reasonably narrow base of support?*

In evaluating this factor, each amputee must be considered as an individual. The length of his stump and his general body type must be

taken into consideration. It is to be expected, for instance, that an obese, endomorphic type of individual will naturally walk with greater abduction than would a thin or muscular person.

In addition, in order to increase lateral stability, it has been the practice to fit very short-above-knee stumps with a prosthesis set in exaggerated valgus (the prosthetic foot outset), which produces a wider base of support.

Occasionally with a pelvic belt wearer, abduction can be caused by the joint being in abduction.

Another cause of abducted gait is pain or pressure in the abductor or ramus region of the socket. The amputee abducts his stump and therefore, the prosthesis, in order to gain relief in these areas. In such cases, abduction is often accompanied by lateral bending of the trunk.

However, there is no reason why the average above-knee amputee, with no physical or prosthetic complications, cannot walk with his base of support as narrow as that of a non-amputee. This is usually between ½ and 2 inches distance between the inner borders of the shoes.

4. *Does the prosthesis swing in a straight line of progression?*

The three major variations of the swing phase of a prosthesis in the sagittal plane are:

a. a medial whip
b. a lateral whip
c. circumduction.

A medial whip is characterized by a movement of the heel of the prosthetic foot medially and a rotation of the knee laterally, noticed immediately after toe-off. The foot then rotates back to its usual position either during the remainder of the swing phase (causing a "fish tail" effect), or returns to its original position by the toe rotating medially immediately after the heel of the prosthesis contacts the ground. A medial whip is corrected by the prosthetist rotating the prosthetic knee medially. In addition to alignment factors, a medial whip may be caused by too tight a socket in the area of the *adductor longus* muscle and tendon.

A lateral whip is the direct reverse of a medial whip, with the heel of the foot moving laterally and the knee rotating medially immediately after toe-off of the prosthesis. A lateral whip is corrected by the prosthetist rotating the prosthetic knee laterally. A whip of this type may be caused by too tight a socket fit in the area of the *gluteus maximus.*

Circumduction is a movement of the prosthesis in a lateral arc during its swing phase. It can be caused by too long a prosthesis, or by the amputee walking with little or no knee flexion and so moving his prosthesis outward in order to assure the foot clearing the ground.

5. *Is the resistance of the rear ankle bumper adequate to prevent foot-slap?*

Too little resistance of the prosthetic ankle to plantar flexion is caused by too soft a rear ankle bumper. The plantar surface of the prosthetic foot therefore strikes the floor too rapidly and with an audible "slap," as the body weight is applied to the prosthesis after heel contact.

6. *Is the resistance of the rear ankle bumper low enough to prevent external rotation of the foot?*

Too much resistance of the prosthetic ankle to plantar flexion is caused by too hard a rear ankle bumper. The plantar surface of the

prosthetic foot is therefore retarded from striking the floor after heel contact, allowing the natural rotation of the leg and body to rotate externally the prosthetic foot before it is flat on the floor. The delay of the sole of the foot in contacting the floor is readily observable as the amputee walks.

7. *Is the toe-out of the prosthetic foot reasonably close to that of the normal foot?*

8. *Is the friction at the knee adequate to control the forward and rearward prosthetic swings?*

The correct setting of knee friction mechanism will do much to eliminate the two major swing phase gait deviations caused by prosthetic inadequacy, i.e., excessive rearward prosthetic heel rise and violent impact at full knee extension.

At the time of toe-off, the amputee flexes his hip, moving his stump and socket forward. Without friction, the shank of the prosthesis has a tendency to remain at rest or to move in a direction opposite that of the stump (Newton's Laws of Motion) depending on the force and speed of hip flexion. The result is excessive rearward heel rise of the prosthetic foot after toe-off.

This excessive heel rise causes, in turn, a time lag in the extension of the prosthetic knee. The amputee finds it necessary to wait for the knee to become extended, and so, for the prosthesis to become weight-bearing. This waiting may cause poor gait characteristics such as *vaulting* (rising on the toe of the normal foot while the prosthesis is in the swing phase) or erratic acceleration (a surging of the entire body with each non-prosthetic step).

Adding friction to the knee creates a more direct relationship between the prosthetic thigh and shank (consider the extreme situation of enough friction to lock the knee in extension) and so the rearward motion of the shank and foot is minimized. Correct adjustment will produce equal heel rise for both the prosthetic and natural legs. (In the natural leg, rearward heel rise is controlled by action of the quadriceps femoris muscles.)

After knee flexion is completed, a prosthesis with no friction at the knee exhibits the characteristics of a pendulum. The shank and foot start the forward swing and gradually increase their speed by means of gravity, but strike the knee extension stop before they are allowed to decelerate naturally (by means of gravity).

In the human body, a gradual deceleration of the shank is accomplished by the hamstring muscles of the thigh. Friction applied to the prosthetic knee acts for the same purpose as the hamstrings although not in the same manner. The friction found in most conventional prosthesis is of a constant type (i.e., acts throughout the swing phase range of the knee), whereas the human muscles act with progressively greater strength, creating what has become known as *terminal deceleration.* (Several prostheses still in experimental stages provide a variable type of friction that more closely approximates muscle functions.)

Also, because of the excessive rearward heel rise and impact at full knee extension caused by lack of friction especially during fast walking, the amputee is forced to restrict his walking speed. The addition of friction at the knee makes it easier for the amputee to walk faster with better prosthetic control and better appearance.

Friction should be adjusted for the amputee's normal walking speed. However, it should not be so great as to require an undue amount of stump effort to fully extend the prosthetic knee. High friction may also tend to cause the foot to "hang up" at the end of the rearward motion. It is the opinion of the authors that with present commercially available prosthetic devices, knee control can be achieved with a fairly high degree of friction and the addition of a knee extension aid (see question 9 below).

9. *If a knee extension mechanism is used, is it properly adjusted?*

The primary functions of an extension aid are: a) to minimize excessive rearward heel rise, and b) to assist gravity in initiating the knee extension movement. As the knee flexes, the extension aid (be it in the form of a kick-strap, hickory lever, wrap spring, coil spring, or compressible bumper) is placed progressively on increasing tension until the tension overrides the force of inertia that is causing the prosthetic heel rise rearward.

Then, due to its tensed condition, the extension aid acts to help gravity initiate and carry out the knee extension movement (forward swing phase).

However, the extension mechanism should not be so tight that it limits knee flexion and causes scuffing of the prosthetic toe. Too tight an adjustment will also tend to bring the shank into full extension with too much force, resulting in a jarring impact on the stump. As previously mentioned, there must be a proper balance of forces between the extension aid and the knee friction.

10. *At the conclusion of this phase of the checkout, have the amputee remove his prosthesis and examine the stump for any irritated or discolored areas, which might indicate need for further prosthetic service.*

In the preceding pages the authors have attempted to present in concise form the highlights of a checkout procedure for above-knee artificial limbs. This checkout is applicable to both suction socket and pelvic belt types of prostheses by simply omitting the few questions that do not apply in either case.

The authors wish to thank members of the Prosthetic Devices Study Staff for their review of this article.

WHAT'S NEWS

The *D. W. Dorrance Co.* and the *A. J. Hosmer Corp.* have had to expand their quarters in San Jose, California, as a result of increased demand for their services.

The Hosmer Corporation has a new building under construction, which will be open April 1. It is just a four minutes' walk up Coleman Avenue from the present Dorrance structure. Mail for the Hosmer Corporation should be addressed to P. O. Box 152, San Jose, California.

The move will make it possible for the D. W. Dorrance Co. to re-organize their present plant and use the addiitonal space vacated by the Hosmer Corporation. All mail for the Dorrance Company should be addressed to 748 Coleman Avenue, San Jose, California (no longer use Post Office Box 1128).

Copies of the new *Construction Manual for the Flexible Soft Socket for Upper Extremity Protheses* are now available. Persons interested should write to Thomas J. Canty, Captain, MC USN, Chief, Amputee Service, U. S. Naval Hospital, Oakland 14, California.