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The Rancho Syme Prosthesis with the Regnell Foot

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The Syme amputation has been with us since 1842, when James Symes developed it for three reasons, "(1) the risk to life will be smaller, (2) a more comfortable stump will be afforded, (3) the limb will be more seemly and useful for ambulation."[1] Since then, the major improvement in the surgical technique has been the introduction of the two stage Syme amputation,[2,3] which was developed to increase the success rate in dysvascular and infected patients. Wagner further refined the technique at Rancho Los Amigos Hospital, and increased his success rate to 95% by the use of Doppler ultrasound to determine adequate blood flow.[4] Wagner also advocates removing the flares of the tibia and fibula during the second stage to narrow the distal end and provide better cosmesis.

The advantages of the Syme level of amputation are many (Figure 1), but the design of the prosthesis has been a constant challenge for prosthetists (Figure 2). The Syme level amputee is typically more active, walks at a faster pace, and expends less energy than the below-knee amputee;[5] for these reasons the demands on the prosthesis are greater. Breakage of Syme prostheses has been a constant problem, especially with prosthetic designs that have openings (medial opening, posterior opening, etc.). Syme prostheses that have no openings must allow enough room for the bulbous end of the leg to pass through, giving a "stovepipe" appearance to the leg. In addition, the "no opening" designs had other advantages, i.e., the silastic bladder expandable wall design was not durable and tended to delaminate, the full insert type added additional bulk to the pros-

Syme Amputation

Advantages

- Natural weight bearing surface
- Some patients can walk a few steps without a prosthesis
- Less energy expenditure than B/K level
- Higher gait velocity than B/K level
- Fewer gait deviations, less therapy than B/K level
- For patients who may lose other leg in the future, the Syme will become the "sound" side
- Fewer prosthetic fitting problems due to discomfort than B/K level

Disadvantages

- Slow healing for many patients
- Bulky distal end-poor cosmesis
- Many patients cannot walk on distal end
- Breakage problems if prosthesis with opening is used

Figure 1.

Syme Prosthesis Design Requirements[6]
1. Transmission of body loads
2. Lightweight
3. Supply foot and ankle function
4. Compensate for leg length discrepancy
5. Distribution of forces developed around ankle
6. Rotational stability
7. Shock absorption
8. Self suspension
9. Ease of donning
10. Adjustabiity for pressure relief
11. Cosmesis
12. Durability

Figure 2.

thesis, and the removable pad design needed constant adjustment.

The Rancho expandable wall prosthesis eliminates many of the problems inherent in other designs. This prosthesis was first described in the AAOS Atlas of Limb Prosthetics although fabrication was not detailed at that time. The Rancho expandable wall prosthesis incorporates the following features:

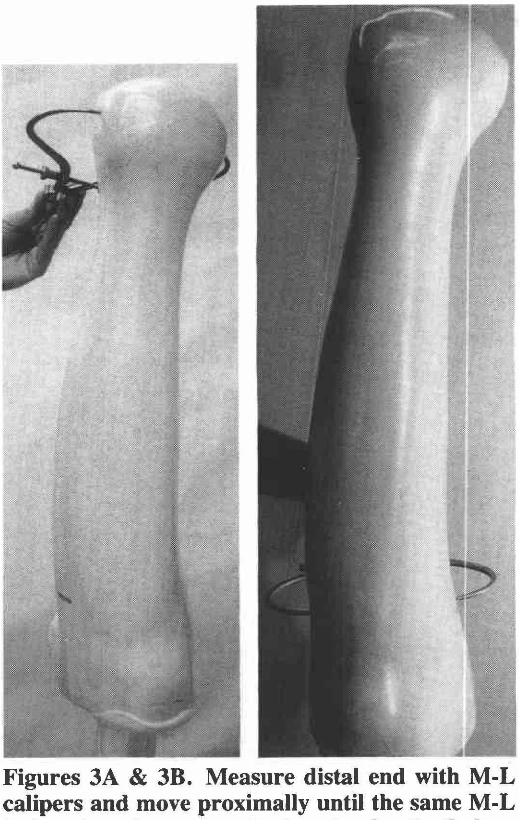
1) **Strength**—The "no opening" design laminated to the Regnell foot provides maximum strength and durability.
2) **Expandable liner**—A durable elastic window sewn in a thin flexible inner liner eliminates problems with silastic or Pelite™ inserts, which will tear or add excess bulk.
3) **Cosmesis**—No buckles or straps are required. No line or seam at ankle joint. Bulk is kept to a minimum with thin wall thickness.
4) **Ease of adjustment**—Although the expandable inner is bonded in place permanently, it can be left unbonded for the first month of wear to allow for adjustments.
5) **Can accommodate large distal ends**—Two expandable windows can be made in the flexible liner to allow for large distal ends.

Negative Impression Procedure and Measurements

The plaster negative impression is taken in the conventional manner. Reliefs are made over the bony prominences by the use of ⅛″ padding before the impression is taken. The circumferences of the distal end and the narrowest part of the ankle should be compared. Maximum cosmesis is attained when the malleoli have been trimmed and the largest circumference at the distal end is about ¾″ greater than the smallest ankle circumference.

Fabrication

After the necessary modifications are made to the positive model, measure the M-L at the distal end, then move the calipers proximally



Figures 3A & 3B. Measure distal end with M-L calipers and move proximally until the same M-L is found to determine the length of polyethylene panels and the buildup needed on the inner socket.

until the model has the same M-L. This will determine the length of the elastic panel (Figures 3A and 3B). If the circumference of the distal end is 1¼″ or greater than the narrowest part of the model, two elastic panels will be necessary.

To allow space for the elastic panel, polyethylene "inserts" (Figures 4A and 4B) are cut to the length determined above, and are inserted between two nylon stockinettes for the expandable liner. The polyethylene inserts are laminated into the nylon using a 80% flexible, 20% rigid resin.

The PVA bag is left on the lamination and a polyurethene foam buildup is made over the lamination (Figure 5); this is then measured and shaped down to ¼″ less than the circumference of the distal end. A PVA bag is pulled over the foam and an outer shell of 6 nylon is laminated using rigid (90-10) resin (Figure 6). After the resin sets, a hole is drilled in the distal end and the outer lamination is forced off the model using compressed air (Figure 7). The polyurethene foam buildup and PVA bag are then removed from the inner lamination.

Remove the polyethylene inserts by drilling small holes in the center of each end and slitting the outer nylon with a razor (Figures 8 and 9). Most of the laminated nylon covering the

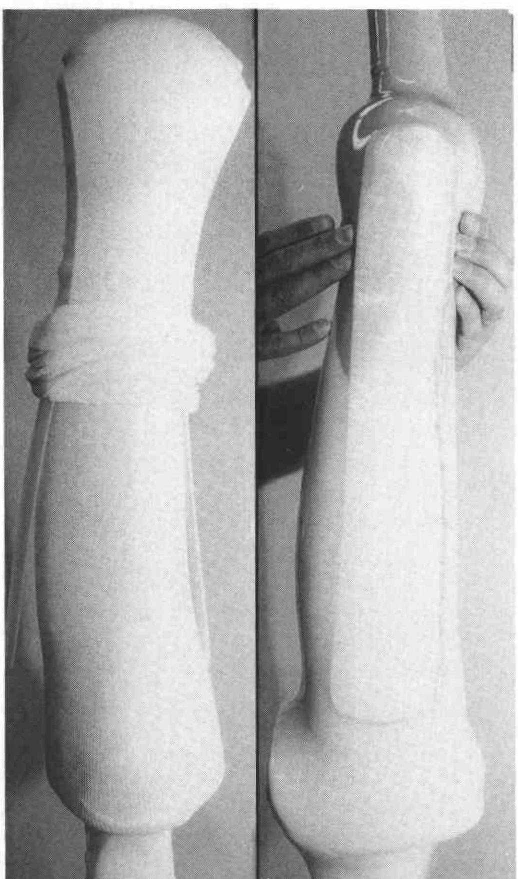


Figure 4A. Medial/lateral polyethylene inserts are inserted between the two points made by the calipers. 4B. Inserts are laminated into expandable bladder using 80% flex and 20% rigid.

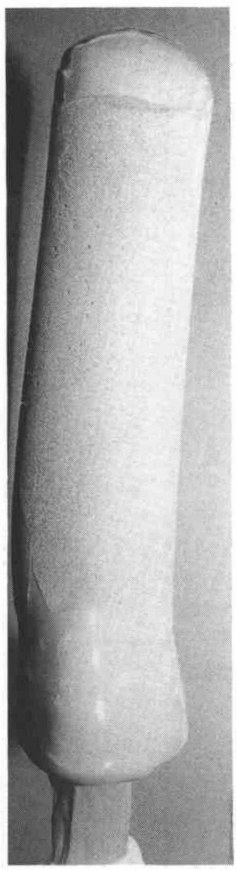


Figure 5. Foam buildup which results in the void necessary for the expandable bladder to open, allowing the patient to don the prosthesis.

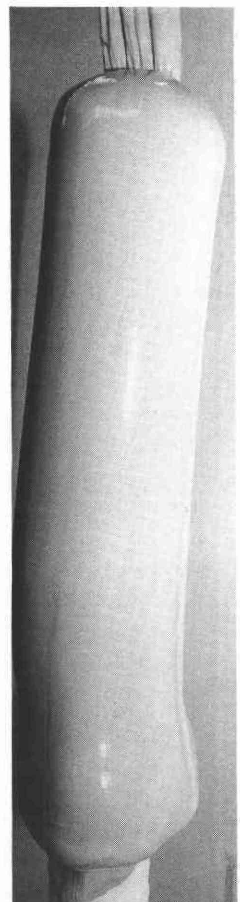


Figure 6. Laminated outer shell over the expandable bladder with the foam buildup.

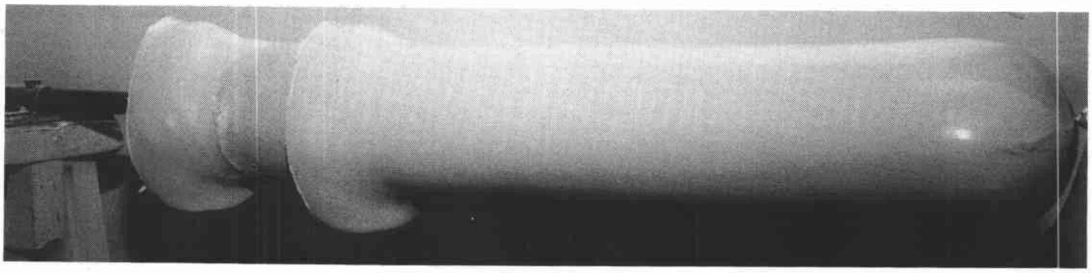


Figure 7. Bladder being pulled out of the laminated outer shell.

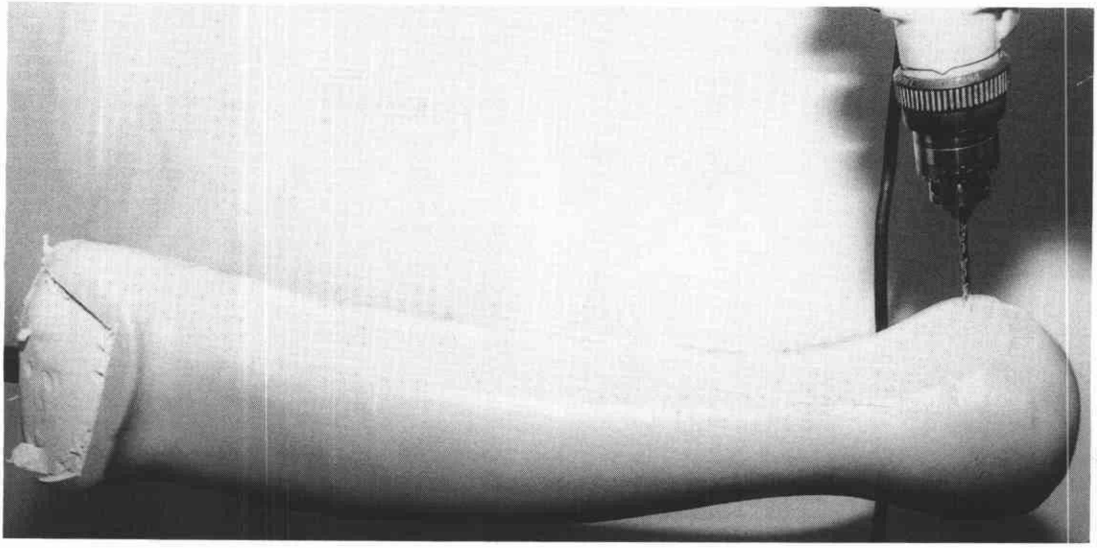


Figure 8. Drilling holes at widest proximal and distal points to properly position the slit in the bladder for the elastic panels.

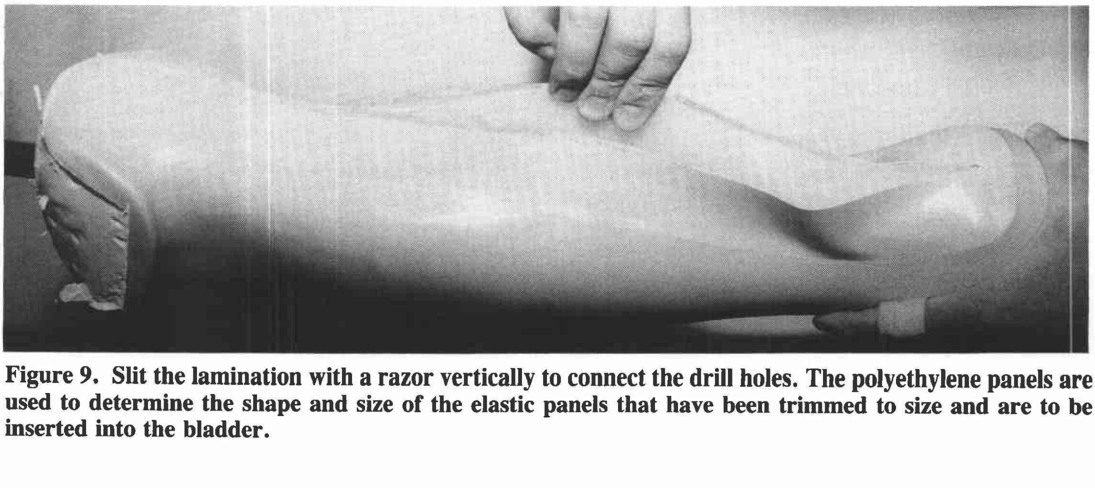


Figure 9. Slit the lamination with a razor vertically to connect the drill holes. The polyethylene panels are used to determine the shape and size of the elastic panels that have been trimmed to size and are to be inserted into the bladder.

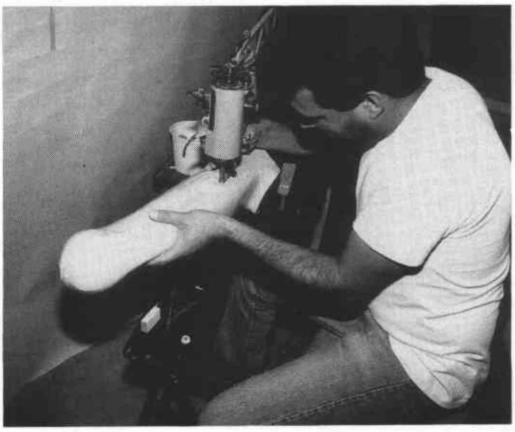
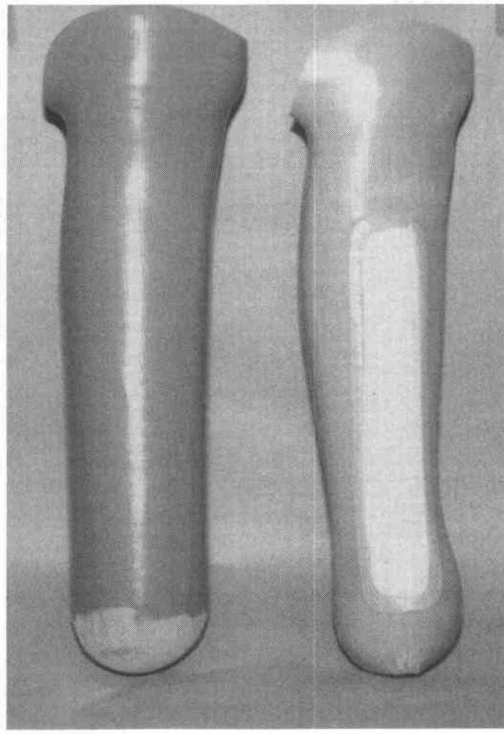


Figure 10. The elastic panels are inserted; it helps to tape them in temporarily at the proper width in preparation for sewing in the elastic.

Figure 11. (right) Outer socket and inner expandable socket with elastic panels sewn in place.



outside of the polyethylene sleeve is removed, leaving a ¼″ overlap to hold the stitching for the elastic panel. A single vertical razor slit is made on the inside of the liner to allow expansion. Use the polyethylene sleeves as patterns to cut out one-way stretch elastic. The proper elastic for this procedure, called grip-net, is difficult to find, as it must have a heavy durable weave and comes in a wide roll (8″ or greater).

The elastic panels are temporarily taped in place and then sewn in place in a long arm patcher sewing machine (Figure 10). The liner may have to be folded and/or lubricated with silicone to allow the machine to reach the end of the insert. The prosthesis is now ready for static alignment on the Regnell foot (Figure 11).

The Regnell foot is an external keel design specifically suited for Syme prostheses because the distal end of the socket can be placed very close to the floor: a thin sole and heel cushion take little space under the prosthesis. No ankle bolt is needed, and the finished laminated external keel provides good cosmesis. The toe break is located and designed to allow for more optimum A-P alignment of the socket, resulting in smoother functional rollover and more cosmetic shaping.

Static Alignment

Static alignment can be set up by either sinking the socket into the keel of the foot, or by cutting off the top of the foot with a bandsaw, leaving only the amount equal to the leg length discrepancy (Figure 12). The socket is then sunk into the block cut-off of the foot and tack glued to the prosthesis (Figure 13). The second method allows the prosthetist easier M-L and A-P and toe-out adjustments by simply moving the block on the prosthesis and regluing. Dynamic alignment is achieved in the usual manner.

Finishing

Following dynamic alignment, the socket is shaped to blend into the foot and roughed up. All soft parts of the foot are taped off and the final lamination of 2 nylon is made. The sole of the foot is not removed during lamination (Figure 14). The lamination is then trimmed away, leaving the sole and toe break free (Figure 15).

The expandable liner is inserted into the outer shell. If no adjustments are anticipated, the liner is bonded to the outer shell at the proximal border with sealing resin.

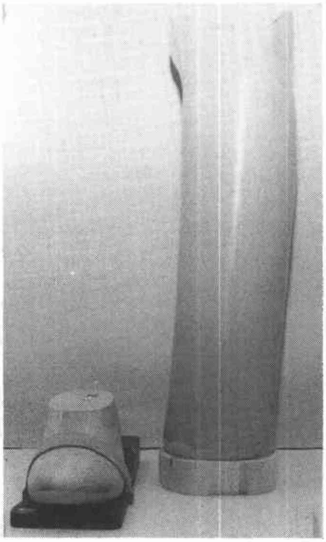


Figure 12. Socket is set into the block, aligned, and glued to the Regnell foot.

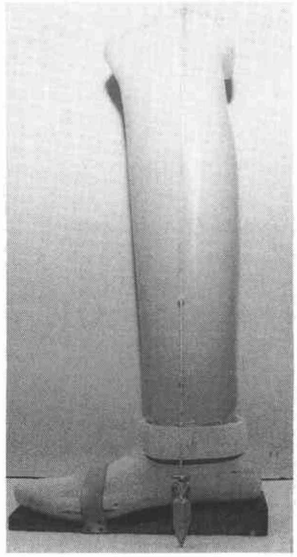


Figure 13. Lateral view of static aligned prosthesis ready for fitting.

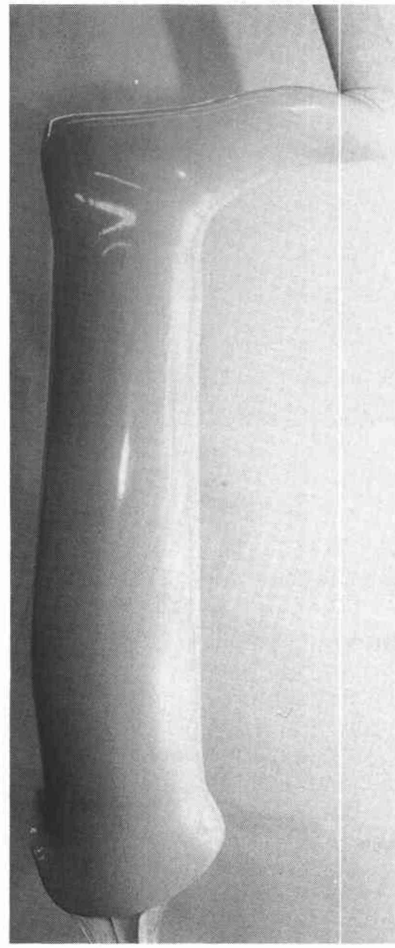


Figure 14. Following dynamic alignment with the patient, the socket is shaped to the foot and made ready for finishing of the outer prosthesis. Two nylons are used with rigid laminate with the sole in place and taped off.

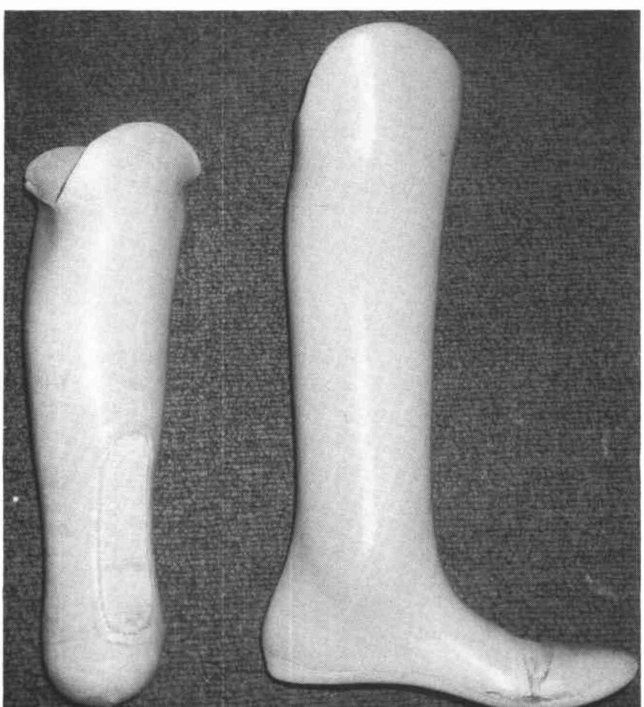


Figure 15. The finished, laminated prosthesis. Expandable liner must be permanently bonded to the outer socket at same point, but can be left separate initially to allow for adjustments.

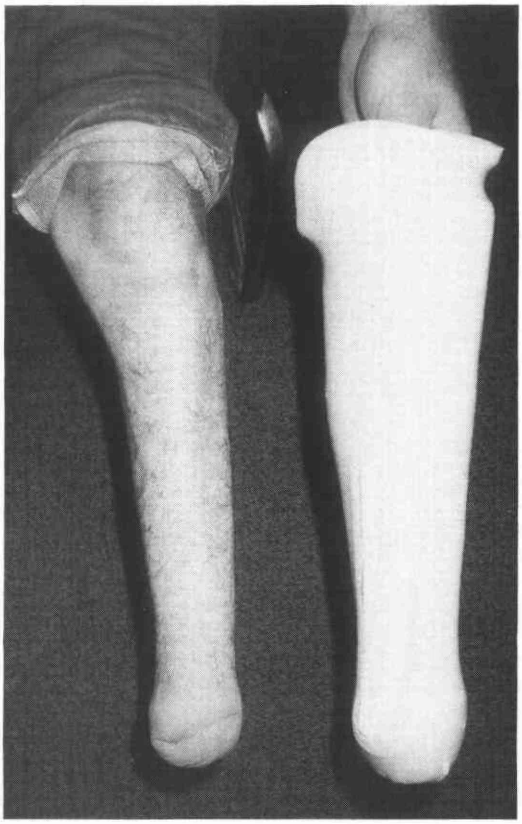


Figure 16. Syme patient holding expandle liner.

Figure 17. Syme patient pulling on the liner. Note the expansion of the elastic panels; normally this would not be seen as the liner would be bonded to the outer socket.

Figure 18. Patient standing on the finished prosthesis.

Summary

The Rancho expandable wall Syme prosthesis, when used with a Regnell foot, provides a very practical solution to the problems existing in other Syme prostheses. Many of the durability and cosmesis problems have been eliminated. Whenever possible, prosthetists should encourage physicians to perform more Syme level amputations, and to try to achieve less bulky distal ends when these amputations are performed.

Acknowledgments

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The fabrication procedure was developed by Orthomedics Central Fabrication, which also provided the fabrication photos.

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