Breaking New Ground Technical Report

Farming with a Lower Extremity Amputation or Impairment

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Introduction

The amputation of a lower limb, the fitting of a prosthesis and the return of the person to their previous occupation evidently has a long history. The Rig-Veda, from India circa 3500-1800 B.C., is claimed to contain the story of Queen Vishpla whose leg was amputated after an injury in battle. After the residual limb healed, she was fitted with an iron leg in order to return to the battlefield. A situation similar to Queen Vishpla's remains today. A number of farmers each year have varying portions of one or more of their lower extremities amputated and like Queen Vishpla return to their occupation, usually with the aid of a prosthesis.

Among the general population in industrialized countries there is typically an amputation population of 1.55 per 1000. Assuming a U.S. population of 260 million, these data suggest the U.S. amputee population to be nearly 400,000. Of this number, lower limb amputees comprise 91.7% of all amputees (53% below knee amputation, 33% above knee amputation, 5.7% partial foot). Furthermore, 75% of amputations result from disease, and 68% of all amputees are over 51 years of age (Northwestern University Prosthetic-Orthodic Center). Among farmers with disabilities, the 1986 Wilkinson survey revealed that 9.6% of the 186 respondents were lower limb amputees. Current statistics for the Iowa FaRM program indicate that 13.2% of their clients have an upper and/or lower body amputation. National Farm Safety Council's data show that 1.5% of all farm injuries requiring professional medical care result in amputations and that the foot, leg, and toe account for 26.3% of the body parts injured.

Although there is no data which indicates the exact number of amputees in the agricultural community, it is widely believed that the per capita amputee population is greater than the general population amputee rate of 1.55/1000. This assumption is derived from the fact that farmers incur a higher rate of disabling injuries than other occupations. In addition, the type of equipment and machinery used in agriculture puts the farmer at risk of an amputation.

This paper focuses on farmers with lower extremity amputations. It is, however, extremely difficult to generalize farmers with leg amputations and prescribe modifications, methods, or assistive technology to accommodate the farmer's individual needs. For example, a farmer with a partial foot amputation has drastically different needs than a bilateral above-the-knee amputee.

As a means of providing information concerning some of the variations in characteristics found, this paper will present an overview with definitions relating to amputations and prostheses, examples of prosthetic devices, characteristics that are common to most all lower limb amputees, and summaries of interviews with active farmers who have lower limb amputation(s). Interviews contain problems being faced and potential solutions as well as other topics. The paper will discuss some generic solutions used on agricultural worksites by lower limb amputees. A brief look at recent prosthetic advancement and a listing of resources is also included.

Definitions

Here are definitions of some common terms used in the prosthetic field regarding lower limb amputees.

Above Knee (AK)—A generic term referring to an amputation occurring above the knee. Technically these occur to the thigh distal (below) to the hip and proximal (above) to the knee joint.

Below Knee (BK)—A generic term referring to an amputation occurring below the knee. Technically these occur to the tibia and fibula distal to the knee joint and proximal to the ankle joint.

Bilateral—Refers to having absent portions on each lower extremity. A bilateral AK would have residual limbs above the knee on both sides. A bilateral AK-BK would have a residual limb above the knee on one side and a residual limb below the knee on the other.

Prosthesis—An artificial replacement worn, in the original place, for an absent body part *(Fig. 1)*.

Socket—The hollow portion of a prosthesis into which the residual limb fits *(Fig. 2)*.

Figure 1. A civil war-era prosthetic leg used by an AK amputee.

Insert—A liner used between the socket and residual limb to help provide for a better fit and additional cushioning *(Fig. 3)*. May be made of various materials.

Stump Socks—Wool or cotton socks made individually for each residual limb and worn with non-suction sockets. The socks are made in various plies, provide protection for the skin and are used to adjust the fit of the socket.

Suspension—A supporting device that assists in maintaining the prosthesis in its proper position. Example: a waist belt and Y-strap for a below- knee prosthesis.

Figure 2. Socket for an AK amputee.

Patellar-Tendon-Bearing (PTB) Prosthesis—The most commonly used design for below-knee amputees. The patellar (knee-cap) tendon is a major weight bearing area.

Quadrilateral Socket—The quadrilateral, ischial-gluteal weight-bearing socket uses the ischial tuberosity of the pelvis and the gluteus maximus muscle as the main weight bearing areas. The most prescribed socket for AK amputees.

Suction Socket—A socket that is in direct contact with the residual limb. A vacuum is created by pulling a sock or bandage from around the residual limb and out a hole in the lower portion of the socket. Advantages of a suction socket include stimulating circulation, somewhat better control and a more natural fit of the prosthesis. Disadvantages are more abrasions to the skin and more difficult to get a proper fit.

Ischial Containment— A socket type in which the lateral (outside) and posterior walls extend higher

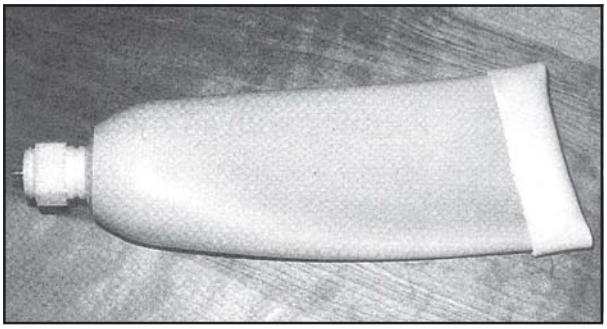

Figure 3. A typical prosthetic insert.

around buttocks and hip to provide more contact area for weight bearing and support to help stabilize the hip region.

Knee Units—The prosthetic knee assists in the control of the below-knee portion of the limb during the swing phase of walking and the stability of the prosthesis during the stance phase.

Knee units can be classified in two types —(1) mechanical friction types, which use the friction of rubbing and are used for amputees who normally walk at one gait and need a lighter knee;

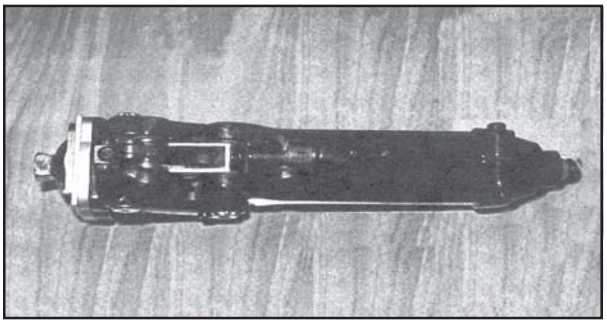

Figure 4. A four-bar prosthetic knee-unit.

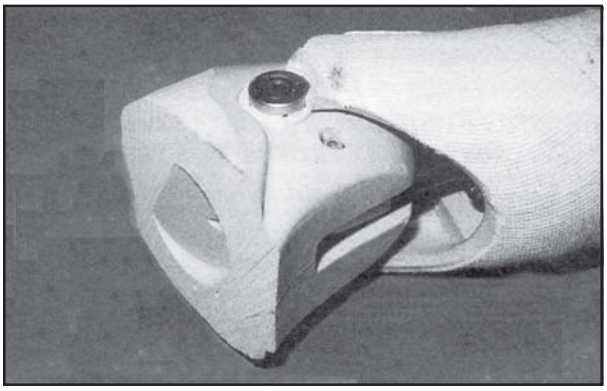

Figure 5. A single-axis knee unit shown in final prosthetic leg.

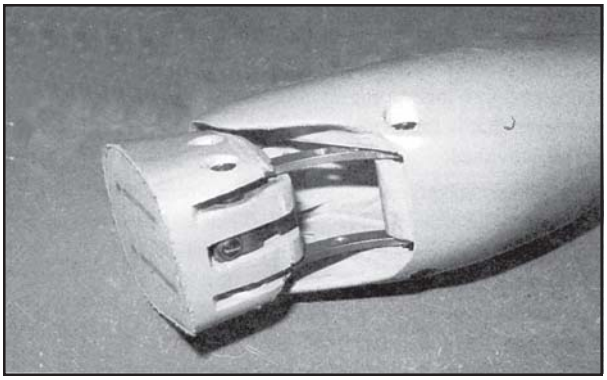

Figure 6. A four-bar knee unit is fitted in the cosmetic prosthesis.

Figure 7. Flex-Foot and cosmetic foot.

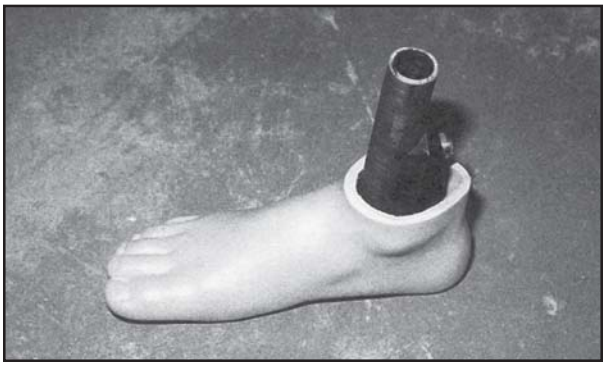

Figure 8. Flex-Foot fitted into the cosmetic foot.

and (2) fluid friction types, which use hydraulics or pneumatics to accommodate varying speeds of gait, are heavier and more costly.

Common knee units sold today include four-bar and single axis knees *(Figs. 4, 5, and 6)*. These knee units are fitted with either pneumatic or hydraulic shocks. A four-bar prosthetic knee is generally more costly than a single axis knee but can provide greater function, and more closely simulate realistic knee action.

Prosthetic Feet—Prosthetic feet substitute for the foot and have an ankle component. They may have a solid ankle cushioned heel (SACH) that has a cushioned heel wedge that compresses on landing to simulate the flexing of the ankle.

The single-axis foot flexes forward (plantar) and toward the shin (dorsi) to simulate the ankle. The multi-axis foot allows movement in all planes. Although more movement is allowed, the harder the foot is to control and the few forces used are transferred directly to the residual limb.

Another type and commonly used prosthetic foot is the spring-leaf type *(Figs. 7 and 8)*. The ad-

vantages of a spring-leaf prosthetic foot include lightweight design and energy storing capability. There are several different models of the spring-leaf foot sold under brand names such as Flex-Foot and Springlite.

Modular Limbs—Refers to a relatively lightweight prosthesis with plastic laminate sockets, tubular pylons (connections) between individual parts and adjustable, interchangeable parts.

Common Charateristics

While each amputation is individual, amputees as a group have several characteristics or problems that are common in various degrees. These include:

- Abrasions of the skin due to rubbing on sockets or socks.
- Settling into the socket as the limb shrinks due to use or weight loss.
- "Pistoning" or withdrawal of the limb from the socket during the swing phase of the gait or from bending to reach or to sit.
- Blistering along suture lines caused by friction between residual limb and sock and/or socket.
- Bruising from suspension devices, crutches, or falling.
- Various ailments arising from the stress and strain put on the remaining body parts as a result of using the prosthesis. Examples include back, hip, and knee pain from trying to maintain a proper posture, hip or knee pain from improper gait patterns, and shoulder and arm pain from use related to compensating for the absent portion.
- Fatigue from the effort required to use the prosthesis. The higher the amputation the more effort required and a bilateral uses more than a unilateral.
- Difficulty traversing uneven terrain and obstacles. The flatter and smoother the surface the better. Unseen depressions and rises of any kind and obstacles such as rocks, holes, corn stalks, and fences can present falling and tripping hazards. The problem is two-fold. First, the absence of muscles and joints in the prosthesis prevent body adjustments causing the whole body to go up, down or sideways. Second, the lack of knowing exactly where the limb is at any particular time. One may think that the limb is at the bottom of the depression (or the top of the rock) when it isn't, leading to a fall.
- Difficulty with varying surface types. For example, the change from a dry surface to a wet surface, from tile to carpet, from concrete to dirt, from grass to weeds, from short grass to tall grass, or from dirt to mud, can create problems. These problems usually include readjusting limb placement and walking gait. An amputee, with experience, adjusts the gait to accommodate the present surface. If the surface changes abruptly, the gait being used may not be what is needed for the present surface (i.e. too long, too fast, etc.)
- Swelling in the stump due to some prosthesis misalignment (from use) or misalignment that occurred when the prosthesis was put on. The body does not always stay the same and occasional adjustments of how the prosthesis fits must be made. If the stump does not fit the socket properly, constriction of vessels may occur causing the stump to swell.
- "Phantom" limb and pain feelings are real and not easily treated by medication. In some cases phantom pain is always present.
- Asked questions from children and unasked questions from adults about one's situation.

Differences

Typically, individuals with similar amputations will experience different problems and have various levels of functionality. The disparity between different levels of amputees is even greater. However, when speaking of the consequences of the procedure itself, the following facts are of interest for AK vs.

BK amputees:

- The residual limb of BK amputees often has a bony protrusion which can be a source of skin difficulties.
- The residual limb of an AK amputee has a thick layer of soft tissue on all sides and is more subject to swelling and shrinking due to weight fluctuations and use. The sensation of the residual limb is usually less impaired.
- Rehabilitation to walking is more successful for a below knee than for an above knee. In general, the more of the limb that remains, the less difficult the rehabilitation.
- The healing rate of the injured area is faster for an AK than a BK amputee. This is due to more tissue mass and blood supply to the area.
- Persistent phantom limb and pain sensations are common in AK amputations.

Farming with a Lower Limb Amputation—*Advice from Davenport (IA) Certified Prosthetist Ken Meier*

Ken believes the first objective of a prosthetist is to provide basic information and education to the amputee concerning their current condition as an amputee. This information should include what the prosthesis is, the implications of the residual limb on prosthetic use, what options are available, and what the procedure will be for fitting the prosthesis. In addition, the prosthetist should provide his insight concerning the available options and how they might be used to address the specific problems of the amputee. The goal is to provide as broad an education as possible for the amputee on their current situation. Next, the prosthetist provides a prosthesis based on the abilities of the amputee incorporating components that will provide a prosthesis that is functional as close as possible to that needed by the individual.

Another objective of the prosthetist is to understand, as well as possible, the occupation of the individual and the effect of that occupation on prosthesis use.

In Ken's work with lower limb amputees who happen to be farmers, the biggest complaints concern rough terrain and heat buildup within the socket. In dealing with the first complaint Ken has found that the *Flex-Foot* prosthesis has proven useful in many farm applications. The *Flex-Foot* is lightweight, made of laminated carbon graphite, and can be attached to the knee unit directly or to a post end. The *Flex-Foot* is a two-piece design with the mounting design curved forward to simulate the toe. The second piece is bolted to the first and extends to the rear to simulate the heel. The advantage of the *Flex-Foot* is that the storage of energy is dependent on the wearer's rate of travel or demand and responds accordingly to provide a fluid gait. The recent availability of a split toe and heel model that allow for inversion and version increases the lateral mobility and stability. Ken is a BK and uses the *Flex-Foot* himself. Because the *Flex-Foot* is non-corroding, waterproof, and durable he and some of his patients wear it without a shoe. Ken has replaced the crepe soul with tire rubber for longer wear.

The second problem of heat buildup within the socket is common to all that wear a prosthesis especially in warm weather. While there are no perfect solutions to the problem and it is often dealt with and treated in different ways, it is the focus of some attention. Ken is working on a socket with a ratchet mechanism in the distal end to be used with a silicone sock that has a prong which fits into the ratchet to hold the sock in place. The silicone sock is rolled onto the residual limb and inserted into the socket, mating the prong with the ratchet. During the day as the stump shrinks it can be forced further into the socket and held in that position by the ratchet until released by an externally located pin. While the process is not completely understood, the stump within the silicone sock does not perspire and seems to remain relatively cool.

Ken's work is an example of how progress is made and refinements to existing products may occur. The primary concern in prosthetics is to understand the abilities and desires of the amputee. It is at this point

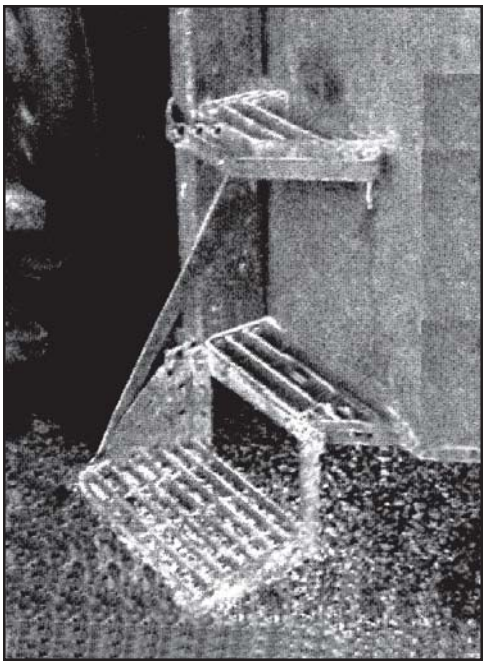

Figure 9. Additional tractor steps allow easier access to the cab.

that the amputee's occupation is considered. Ken's experience with amputees as farmers is similar to his work with amputees who are not, each is an individual with one unique characteristics that must be accommodated. Farmers have unique characteristics whether they are amputees or not. It is the combination of these two factors that make each farmer with a lower limb amputation a client with very specific requirements that can only be addressed through time and trial of products until the optimum prosthesis is supplied.

Case Studies

The following cases are of farmers and agricultural workers who continued to work after their leg amputations. The different cases include a variety of amputations and types of farming operations.

Lyle Buzzard (St. Elmo, IL)

Lyle Buzzard farms 2,550 acres with his family and a hired hand. Wife Gloria, son Dean, and father Ayres are all actively involved in the operation. Gloria also operates a hair salon in her spare time.

Lyle lost his right leg BK and his left leg AK in 1969. His glove was caught in one of the silage wagon's beaters while he was oiling it for storage. He was pulled between the beaters bending his legs backwards. Lyle says the accident resulted from being in too big a hurry to complete the task, and not shutting off the machinery prior to servicing.

Lyle has made several modifications to his farm operation which have enabled him to remain relatively independent. For easier access, he has added an extra step to the ladders on his tractors, combine, and sprayer *(Fig. 9)*. All of the farm trucks have automatic transmissions, and a four-wheel ATV is used for short trips around the farm and for bird hunting. Since Lyle's son Dean started farming full time, he has assumed many of the heavier tasks that were formerly Gloria's. After the accident, an Allis Chalmers tractor was equipped with hand controls, and a combine was equipped with an electric winch lift. Lyle eventually removed the lift because it was too slow. He uses arm strength to assist his right knee to climb the ladders into his equipment *(Fig. 10 and 11)*. Also, because of the remaining knee, Lyle does not have a restriction on his driver's license. The purchase of tractors equipped with power shift transmissions and hydraulic brakes has eliminated the need for Lyle to equip his machinery with hand controls.

Lyle uses a PTB prosthesis with corset on the right side and a quadrilateral socket, stump socks, and safety knee on the left. Both sides use SACH feet and Hush Puppy shoes. Lyle has continued to use these types because they hold up better to the hard

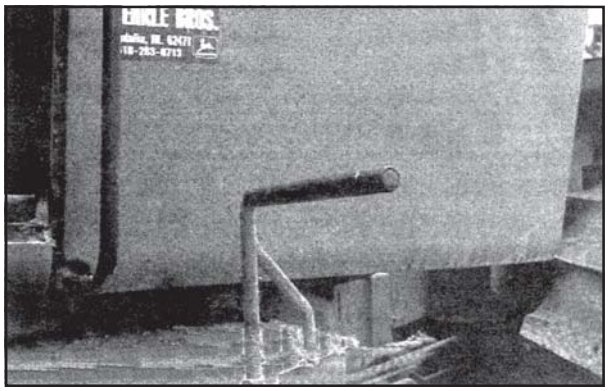

Figure 10. A well-placed handle facilitates climbing ladders and helps balance the user.

Figure 11. A series of handles on the steps increases the ease of climbing.

use he gives them as opposed to the other types and sockets he has tried.

Lyle experiences the usual problems associated with prosthesis use but has experienced few other health problems. His biggest problem is the pain associated with the first steps taken each day, particularly in his right knee which was damaged in the accident. To help eliminate skin problems, Lyle has learned to keep the areas as clean as possible. During long days he sometimes baths midday to clean the residual limbs of dirt and sweat.

Lyle credits both his family and community with providing support and encouragement after his injury. He goes on to say Gloria has been the main support in his recovery and continuing efforts. The process would have been much more difficult without her support and presence.

Lyle believes one of the hardest mental adjustments is accepting the situation and admitting that there are things you can no longer do. Another difficulty is having to accept being treated differently by others. He related speaking with equipment dealers at farm shows only to be left mid-sentence for someone else without any apparent physical problems. The assumption being that since Lyle has a disability he really would not need the equipment anyway.

Ralph Kauffman (Atlanta, IN)

Ralph Kauffman farms 525 acres and raises 2,400 head of hogs farrow-to-finish with his wife Bobbie. In addition he has a nearly full time seed business and sells crop and hail insurance. Bobbie also has a tasty barbecue (BobbieQ) business.

Ralph lost his right leg BK, in 1976, while cutting down a tree. The treetop caught the top of another tree and shot back into his leg.

The modifications Ralph uses include a forklift to assist in loading and unloading pallets of seed and other heavy items. The step on his Bobcat skid steer loader has been moved forward to allow better access to the foot pedals *(Fig. 12)*. Ralph lets oth-

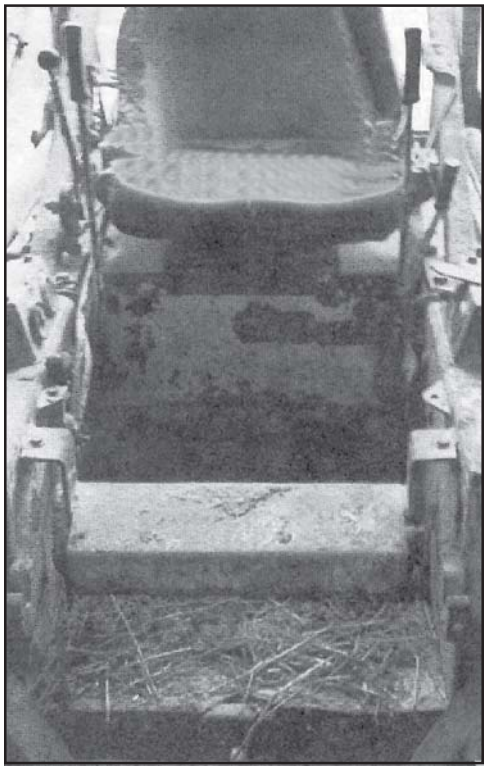

Figure 12. Moving the steps on a skid-steer forward allows easier access to the control pedals.

Figure 13. Livestock and service dogs not only play basketball, but can assist with many chores.

ers do the combining, giving him more time for management duties. He favors a four-wheel drive pickup for work and a split front seat in the family vehicle. The swine operation is moving to total confinement to localize the management as well as eliminate the terrain and weather problems for Ralph. Bobbie continues to do the "running" for things as did their three daughters when they were at home. A main addition after the accident in handling the animals was a working Australian Shepherd dog for herding. Ralph's Border collie continues this work as well as being a fair basketball player *(Fig. 13)*.

Ralph uses a PTB type prosthesis with a vinyl insert for total contact. Two sleeves which extend from the outside of the limb onto the thigh allow for suction support. A multi-axis foot is used. A revision surgery to fuse the tibia and fibula and arrange muscle groups to assist circulation allows Ralph's residual limb to bear 60 percent of the weight on the end. Ralph uses Nike hiking boots for their all-around traction.

In addition to the usual difficulties associated with prosthesis, Ralph also has encountered problems with staph infections. These infections have led to several doctor and hospital visits. Ralph also feels that hereditary high blood pressure and migraines have been aggravated by the amputation. He has learned that abrasions and cuts need to be tended to immediately and good hygiene can help prevent infections. Ralph does not recommend hopping on the good leg without the prosthesis. He believes that special attention should be given to the good leg because he is now more dependent on it.

Ralph feels that the community support was important in his recovery. After the injury several neighbors gathered to help harvest crops. Two neighbors who have amputations were examples for Ralph, and they encouraged him to continue farming.

Bobbie, however, is given the most credit for support and encouragement after the injury and assisting with the farm operation. After Ralph's initial dissatisfaction with his doctor and prosthesis he feels very strongly that a good doctor and prosthetist is of the utmost importance in recovery and second opinions are a necessity.

Kent Richards (North Manchester, IN)

Kent Richards finishes 1,400 head of feeder pigs and 350 head of feeder cattle on his 620-acre farm. He runs the operation with his father, his wife and their small son *(Fig. 14)*.

Kent lost the front half of his left foot in an accident with a self-propelled silage chopper in 1989. While chopping the last load of silage the chopper head became plugged. After disengaging the header but leaving the engine running, Kent was kicking the stalks from the head when the lever vibrated into the engaged position restarting the head. Fortunately, Kent was close enough to the platform to reach underneath and pull on the linkage to disengage the head. Kent had always been cautious around machinery, particularly concerning getting his hands pinched. He has seen many older farmers missing

Figure 14. Kent Richards takes a break from farming to spend some time with his son.

Figure 15. Velcro attachments make wearing cowboy boots on a prosthetic foot convenient.

portions of their hands. Consequently, he was using his feet rather than his hands to unplug the machine.

Kent has made few modifications to his operation. One change however has involved the removal of the step on his skid-steer loader. The step made access to the bucket dump pedal difficult since his prosthesis does not allow the motion needed for normal activation.

Kent uses a Symes prosthesis, A PTB type with a flex foot using a spring coil to allow for multi-axis rotation. The Symes procedure involves a disarticulation of the ankle joint. Kent's doctor recommended the removal of the remainder of his foot for faster healing. Also the residual limb should withstand Kent's anticipated activity level better. In Kent's case, 1/3 of the weight is borne on the patellar tendon and 2/3 on the limb end. He normally wears lace-up work boots but is experimenting with using velcro on the outside seam of a cowboy boot so he can use his preferred footwear *(Fig. 15)*.

Kent has experienced relatively few problems as a result of the injury. He has found that he consciously paces himself during peak farm periods. He also will change stump socks during long days.

After his injury, a seed dealer friend who knew another person with an amputation introduced Kent to him. Kent feels it helped to meet someone with a similar situation. This was not his first introduction to disabilities though. Kent grew up knowing a boy born without arms. The boy was included in many activities so Kent felt that his condition presented few limitations. The local community was also supportive of Kent particularly at the stage when he could get around but not do much. Sitting at the coffee shop talking with other farmers allowed Kent to still feel involved. Kent's wife was his most important support after the injury both personally and through her willingness to take on many farm management activities.

Kent feels that acceptance of the situation is important to continuing with one's life. He also feels fortunate to have had a good doctor who knew what was likely to be best for him in the long run.

Brenda Besse (Erie, IL)

Brenda, 37, assists seasonally in the 2,000-acre family grain farm operation that includes her father, brother, and a hired man *(Fig. 16)*. She also has a full-time position at the Civilian Personnel Office at the Rock Island, IL, Arsenal.

Brenda lost her right leg AK in 1981. While harvesting corn it appeared that the gathering chains and the feeder house became plugged. After repeatedly backing up and shaking the corn head to no avail, Brenda left the head engaged and got out of the combine. At the front of the head she stayed what seemed a safe distance away and began to pull the stalks off the snouts on the head. The combine crept forward until her leg was grabbed by the gathering chains, so in response she turned herself around so that she was able to hold onto the snouts while attempting to pull herself out. Brenda pulled and then rested repeatedly until her leg fell to the ground hence freeing her from the machine. She then climbed back into the combine and drove herself to the end of the field where her dad was waiting in the grain semi-truck.

Figure 16. Brenda on the family farm.

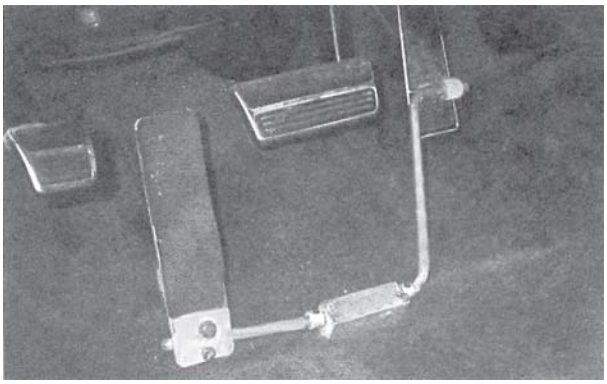

Figure 17. A simple pedal modification to the accelerator in Brenda's automobile allows it to be depressed with the left foot.

No modifications have yet been made to any of the farm equipment. Brenda does not operate the combine anymore, but did run the "mangler" combine about a month after the injury. When mounting the larger equipment, Brenda now jumps to the first step while pulling with her arms. She admits to being much stronger now in the upper body. Brenda has modified her car by installing a left foot accelerator pedal to prevent having to cross her legs to operate the pedals *(Fig. 17)*. The modification can be moved to a new vehicle when needed.

Brenda uses an Endolite Sport Leg which has an ischial containment socket mounted on the Endolite carbon fiber, with knee and post component. The foot attachment uses rubber snubbers in the ankle to allow flexing in all directions. Brenda credits the lightweight Endolite with not only leaving her with more energy at the end of the day but also with providing a psychological boost. She "hated" her previous prosthetic devices and the Endolite prosthesis has allowed her to pursue a favorite family activity of golfing, at which she has won several tournaments across the country. With the use of the Endolite prosthesis, Brenda feels she has regained some of the athleticism she lost with the amputation and now continues to practice her golf strokes.

Brenda has experienced the usual problems associated with prosthesis use including skin abrasions and physical fatigue. She had major occurrences of phantom pains after the amputation. Brenda says she is now generally more attentive as is necessary with using prostheses and is perhaps more careful. One result of the amputation is a slower overall pace.

Brenda credits her family with providing her with support after the injury. Her mother, in particular, was present to provide encouragement which was needed at the time.

Brenda believes her biggest problem has been the lack of mobility. Brenda was very athletic and played basketball at the high school and college level. She received her degree in health and physical education but after the injury she was no longer interested in that area as a career. An article in the local paper about her injury prompted an offer for a position at the Rock Island Arsenal where she has been a federal employee for 13 years.

Chip Petrea (Urbana, IL)

Chip Petrea currently lives in Urbana with his wife Susan, and sons Tiras and Zachary. He left the family registered Jersey dairy farm in 1987 to continue his education at the University of Illinois.

Chip lost both legs AK in 1978. Using a large round baler to bale soybeans for hay, the foliage contained enough moisture to make it difficult for the rows of soybean vines to be pulled between the counter-rotating belts as needed to begin a bale. After shutting off the baler several times to remove the soybeans, Chip decided to drag a mound of beans in front of the pickup fingers and use his feet to push on the beans to help force them between the belts. Although the effort was successful, his right foot was also pulled between the belts. Still standing, Chip could pull his right foot partially out but could not pull the steel toe of the boot back out against the force of the belts. After trying unsuccessfully to lasso the PTO engagement lever on the back of the tractor, fatigue and the pull of the belts pulled Chip down onto the pickup fingers and eventually pulled his left leg between the belts also. He wrapped his right arm around a support bar and held onto it with his left hand essentially keeping himself from being pulled further into the baler. The fact that the legs were crushed and the heat from the friction of the belts cauterized the wounds kept him from bleed-

Figure 18. Chip outfitted his International 186 with a standing platform left after his injury.

ing to death. Chip wishes he had shut the baler off one more time.

The modifications Chip used were both equipment and task in nature. The equipment modifications were a hydraulic lift on one of the large tractors which required reversing the direction the door opened *(Fig. 18)*. Hand controls for brakes and hydraulic levers were also installed. A small tractor used to clean out barns was equipped with a hand control on the clutch. The other two smaller tractors were operated by lifting a prosthesis and placing it on the pedal needed and then pushing down on it with a hand. Milking equipment was purchased that would better accommodate a person in a wheelchair and placed at an appropriate height. Both family vehicles were equipped with left hand controls. One task modification was for Chip to take over the record keeping from his older brother. Others included placing Chip on the tractor task that required the least getting off, such as loading manure, disking, mowing, etc. Help was needed in hooking up equipment and was sometimes simply done by someone else. Another change was for Chip to do more of the running after parts which left the others for the more manual tasks.

When he was farming, Chip used quadrilateral suction sockets in modular limbs with Otto Bach knees and SACH feet, aided by two Canadian crutches. Lace-up work boots were the choice for footwear because the reinforced heels withstood the lateral force in turning the best. A wheelchair was kept in the milking parlor for milking. He found that the back and forth of letting cows in and out and tending milkers was most easily accomplished this way.

Chip experienced the usual problems with prosthesis use with the main two being exertion from using the limbs and perspiration. The sweat would accumulate in the bottom of the socket and whenever Chip sat the sweat would run toward the socket opening and break the suction seal. The best answer found was to put sections of disposable diapers in the bottom of the socket. The reacting material would hold the perspiration in place. No solution was found for the exertion problem except not to use the limbs (which did not always help). Keeping bolts and screws tightened on the limbs required having metric sockets and Allen wrenches readily available.

Both his family and the local community were supportive after the amputations. The community immediately responded by coming to complete the harvesting that was taking place. In addition, a woman that Chip did not know organized a fund drive from local churches and a community group collected funds that paid for a four-wheel drive pickup. Chip is still humbled by the response. Susan has and continues to bear the brunt of Chip's physical and emotional recovery and words fail to describe her importance. The remainder of his family have all played important roles especially his mother and older brother.

Ron Carpenter (Millersburg, IN)

Ron Carpenter and his brother, Richard, farm 40-50 acres of corn, soybeans and wheat. Ron has a full-time job as a bookkeeper for a local business and farms part time with his brother. He also helps out on his parent's farm when needed.

Ron lost his left leg when he, his brother, and their father were cleaning a grain bin in 1975. A floor auger caught Ron's heel and he became entangled. He was 12 years old.

Equipment modifications that Ron uses include a hand clutch lever for their John Deere 2510 tractor.

For Ron, the idea to use a hand control came from information sent to him by the Breaking New Ground Resource Center in 1989. He now cites the clutch hand control as the most helpful modification he has made. One other "modification" Ron uses is their John Deere 3020 tractor with power shift. He likes being able to drive it without the need for using a clutch. Ron also purchased a commercial product to convert the foot-operated shift lever on his ATV to hand operation.

The prosthesis Ron wears uses a suction socket and a modular design with a hinged knee. Foam covers in the shape of a human leg can be attached to the prosthesis, but Ron does not like them. He says they are not durable — lasting 2 to 3 years for him— and they are expensive (about $500 for one).

Ron mentions harrowing after plowing and climbing into grain bins (top or side) as specific areas where he encounters problems, although he continues to perform these jobs. He describes his biggest challenge as trying to locate an affordable grain truck with an automatic transmission. The solution came with the purchase of an old street department truck converted to use as a grain truck.

The support Ron received from his family was helpful to him in getting back to work on the farm. Friends of the family who have amputations did contact his parents to offer support, but Ron feels his being only 12 years old at the time kept those friends from speaking with him directly.

Ron's advice to new amputees: don't be afraid to try things. He figured out many things about living with an amputation through trial and error. Ron also credits his family with encouraging him to try things, too. If you can overcome that fear of failure, he says, you'll make plenty of accomplishments.

Ron says he can wear any shoe with less than a 1/2 or 3/4-inch heel, but the added weight of heavy work boots makes them too tiring for him. Tennis shoes are his favorite shoes now.

Terry Smalley (Fairmount, IN)

Terry Smalley and his wife, Sylvia, rented out their 40 acres of farmland for the first time in 1992. They sold their 500-head swine herd three years ago. Terry continues to work full-time at a General Motors plant.

Terry's left leg and hip were amputated in 1987 to remove cancer. Terry wanted to continue farming; and with help from Sylvia, their sons, and Terry's father, they continued to plant and harvest crops and manage their swine herd.

Terry, frustrated that he could not help significantly with the swine operation, sold the herd after two or three years. After his father had a heart attack in 1991, Terry tried to continue without that help. With his children and him working full-time off-farm jobs, and with Sylvia unable to perform the same physical labor that Terry's father had done, there was simply no longer enough time to complete all the necessary tasks. Terry and Sylvia decided to rent their land beginning in 1992.

When Terry retires from his full-time job, he hopes to return to farming. He believes that without the time constraints that were imposed by his other job, there may be sufficient time to allow him to perform tasks at the slower pace he is forced to work at because of his amputation.

Case Study Summary

As can be seen from the individual interviews, each of the farmers with a lower limb amputation has similarities and differences from the others. All those interviewed relied heavily on their families, particularly the spouse when married. Each had instances of job or task realignment. All indicated that the community had been supportive of them, several indicated help with chores or harvest after the injury. All indicated that their injuries had slowed their general pace of doing activities. All indicated that good hygiene had become an important item and was a necessity to continue working. When viewed as a group and compared to upper extremity amputees, relatively few equipment modifications had been performed.

Differences between the individuals were also ap-

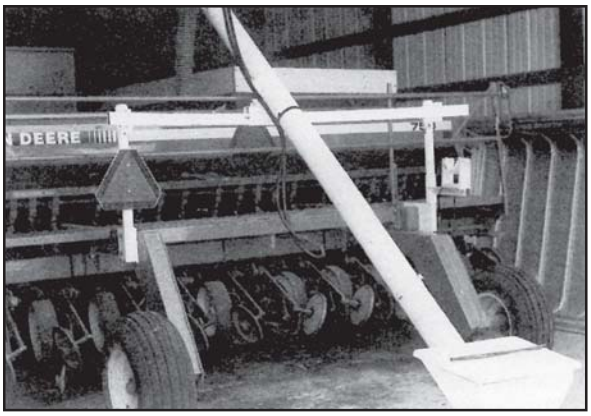

Figure 19. Seed handling system fitted on a no-till drill.

parent. The type of prosthesis used varied, even for those with similar amputations. The type of shoe used on the prosthesis was subject to individual preference and activity. The number of modifications employed increased with the height and number of amputations. The type of modifications employed depended on the family situation, the farm enterprise, the amount of residual limb and many other factors. When taken together, the similarities and differences indicate that each individual may or may not address needs the same as another and that there is no right answer to what should be done; only those that work.

Generic Solutions

Many farmers with lower extremity amputations discover that very few, if any, modifications are necessary to continue farming. Often they have lost little mobility due to the amputation and do not experience physical pain related to the residual limb.

In other cases, farmers who experience a lack of mobility, or balance, and consistent pain will seek means of alleviating these problems through worksite and equipment modifications. Farm modifications implemented to assist a farmer with lower extremity amputations are ofter similiar to those used by farmers with spinal cord injuries, arthritis in the knees, or hip replacements. Many of these changes or modifications will benefit not only the amputee but also his/her able-bodied co-workers as well.

For example, a seed handling system eases the burden of climbing on and filling a grain drill with 50-pound bags of seed for everyone involved in the farm operation — not only the amputee *(Fig. 19)*.

Although making the farm operation more accessible can be costly, a majority of modifications require little money or can be built in the farm shop or by a local machinist. Mechanical hand controls for tractors and other machinery are a prime example of low-cost assistive technology that can be fabricated in the shop or purchased commercially for around $50 per lever.

Another challenge to a lower limb amputee is climbing ladders and other structures such as grain bins. Climbing can be reduced or eliminated on grain bins by using simple devices which indicate the grain level in the bin *(Fig. 20)*. Two examples of these devices are the EZ-Eye and the Saf-T-Fil.

Although devices such as these can be used to elimi-

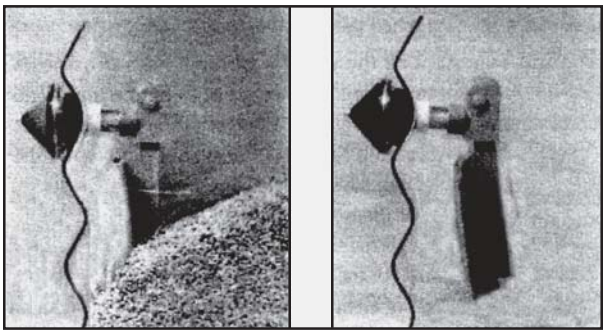

Figure 20. Grain level monitor changes color.

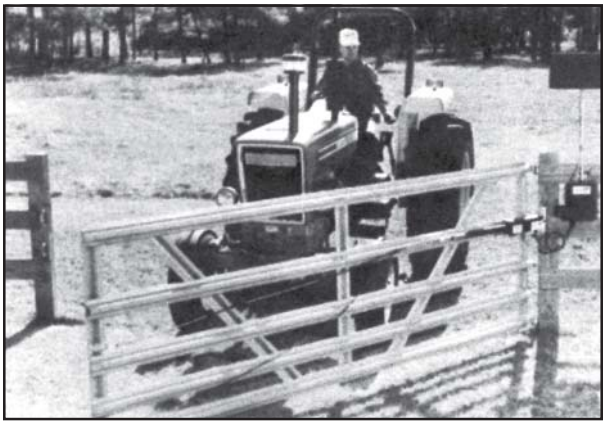

Figure 21. Even gates without access to electricity can be converted to automatic swing gates powered by solar energy or battery cells.

Figure 22. Bilateral amputees may consider the installation of a chairlift on tractors if climbing ladders is difficult or impossible.

nate climbing ladders under certain circumstances, the farmer may consider replacing ladders used frequently with stairs accompanied by a secure hand rail. In other situations the best solution may be to have others perform operations involving climbing.

Another device commonly used by lower limb amputees is automatic gate openers *(Fig. 21)*. Gate openers eliminate the extra processes of having to get out of the truck or tractor, open the gate, and re-close the gate once the operator drives through.

Drive-through gates are also an option in pasture settings or with docile animals. These type of gates are available in several different designs. Typically, drive-through gates are constructed of a material that flexes as the vehicle enters and then returns to the original position once the vehicle has passed. Another design is rigidly built cantilever beams mounted with steel springs to hold the gate in place and still allow a vehicle to pass; this type is typically electrified to deter livestock from pushing them open. Still another design is a simple grate with a pit dug below. Livestock will not cross a well designed grate but tractors and trucks can still drive over them.

For the leg amputee experiencing extreme difficulty with mounting tractors or other equipment on the farm, more expensive assistive technology such as tractor platform lift or chair lift may be implemented *(Fig. 22)*. Such lifts are able to lift an operator from ground level to the operator's station of a tractor or combine by means of a ball screw-drive, electric winch, linear actuator, or hydraulic cylinder. Tractor lifts can be built on the farm, by machine shops, or purchased from a commercial installer.

A less costly solution to accessing agricultural machinery is to simply change the arrangements of steps to the cab or attach additional steps to the original equipment manufacturer's steps. Staggered steps have been successfully used by leg amputees, especially AK amputees. Additional hand rails are included with many after-market tractor steps and should be considered whenever steps are added because of the extra measure of safety and convenience they add.

Use of all-terrain vehicles (ATV's) can be extremely helpful to farmers with leg amputations for a variety of purposes. A few tasks for which an ATV can be used include: scouting crops, checking on livestock, hauling loads, spraying crops, or simply as a mobility aid for the farmer or rancher. ATV accessories including dump buckets, fertilizer and seed spreaders, and spot sprayers also ease certain tasks which are difficult for the amputee. Hand controls which replace foot shifters or pedals are readily available for the amputee who has difficulty using his /her prosthesis for fine movement. Additional safety measures such as adding foot guards should be considered if there is a risk of the operator's prosthetic limb slipping off the standard foot peg.

If operation of an ATV is not practical, powered or manual carts can prevent undue force on the residual limb caused by carrying heavy loads by hand.

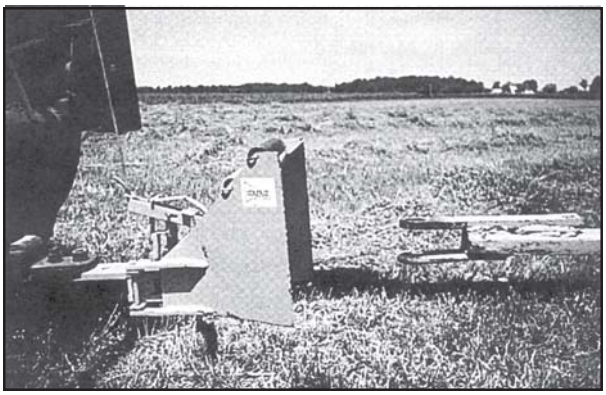

Figure 23. Automatic hitches allow hitching and unhitching from the driver's seat.

Automatic hitches save time and also reduce climbing on and off tractors when hitching an implement that attaches to the tractor drawbar *(Fig. 23)*. To hitch up the implement, the farmer simply backs the tractor until the hitching device locks into place.

If livestock is a part of the farm operation, a well-trained dog may ease the burden and stresses of handling sheep and cattle in particular situations. A livestock dog can herd animals according to the farmer or rancher's commands. A reliable dog can save much of the chasing and aggravation associated with handling livestock.

Recent Advancements in Lower Limb Prosthetics

The most crucial part of obtaining a comfortable and useful lower-limb prosthesis is to ensure that the stump forms a comfortable fit in the socket. To assist in this delicate process, prosthetists have enlisted the use of computer aided design and manufacturing techniques. Computers have allowed greater precision in fitting the residual limb to the socket in the prosthesis.

Another recent development in lower limb prosthetics is flexible artificial feet. These flexible feet behave more like a natural foot and reduce shock on the residual limb.

Advancements have also been made in the design of artificial knees. The movement of newly developed knee joints are easier for the amputee thanks to improved kinematics.

References for Farmers with Lower Limb Amputations

No one, especially farmers, need to feel that they are plowing new ground following a lower limb amputation. There are excellent resources, willing mentors, and competent professionals who can help make the transition back to independence and work easier. The following are a few sources that should be helpful.

[1] National Amputation Foundation
73 Church Street
Malverne, NY 11565

[2] After Rehabilitation and Training Center for Limb-Birth Deficiencies/Amputations
8408 West McNab Road
Tamarac, FL 33321
(305) 721-1140

[3] U.S. Amputee Athletic Association
P.O. Box 15258
Colorado Springs, CO 80935
(719) 597-6568

[4] National Amputee Golf Association
P.O. Box 580l
Coralville, IA 52241
(800) 633-6242

[5] The Amputee Coalition of America
Administrative Office
6300 River Road, Suite 727
Rosemont, IL 60018
(708) 698-1633

[6] National Amputee Summer Sports Assoc.
215 West 92nd Street
New York, NY 10025
(212) 874-4138

[7] American Amputee Foundation
Box 250218, Hillcrest Station
Little Rock, AR 72225
(501) 666-2523

[8] Disabled Sportsman of America
P.O. Box 26
Vinton, VA 24179

[9] Breaking New Ground Resource Center
Purdue University
Agricultural Engineering Building
225 S. University Street
West Lafayette, IN 47907-2064
(800) 825-4264

[10] RESNA
North Moore Street, Suite 1540
Arlington, VA 22209-1903
(703) 524-6686

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