From the Medical Director

Reconstructive Amputation Techniques:

Hope, Hype and Reality

by Douglas G. Smith, MD

"In theory, there is no difference between theory and practice. But in practice, there is."

- Jan L.A. van de Snepscheut, computer scientist, mathematician

The injuries and diseases leading to amputation are quite complex, and amputation surgery is not always straightforward or easy. Under different circumstances, certain tissues may or may not be available for reconstructive efforts. Amputation surgery demands careful attention to skin, muscle, nerves, vessels and bone. Good technique can maximize the chance of having the best residual limb possible with which to interact with a prosthesis and the outside world. It takes all the insights and experience of the surgical and rehabilitation team to specifically tailor surgery and rehab for each individual as much as possible. Life for everyone involved would be much easier if one approach were appropriate for everybody. But one size does not fit all. There simply is no single surgical technique that works every time for everybody.

Amputation removes all or part of a limb, and because of its destructive appearance, people often find it difficult to view it as a reconstructive act. Amputation surgery is not glamorous. While disease, injury or dysfunction makes amputation necessary, the decision to proceed with amputation and the decisions regarding surgical level and technique remain difficult. Putting it bluntly, surgeons hate making these decisions. As a result, amputation often is seen as a failure, and, unfortunately, many amputation surgeries are performed only in this negative light. I believe it is a mistake to look at it this way. The reconstructive side of amputation surgery must always be considered. While there are times when the reconstruction must be delayed because of severe wounds, contamination or infection, it must not be forgotten. The goals of reconstructive amputation surgery and rehabilitation must include the following:

- Removing the disease or pathology
- Appropriately addressing the skin, blood vessels and nerves
- Stabilizing the muscle and maximizing the padding of the amputation
- Properly treating the bone
- Managing the healing process and appropriately treating areas that don't heal
- Restoring life through rehabilitation and prosthetic limb replacement.

The Hope

One of our foremost hopes over the years has been to find ways for people with amputations through the calf or thigh to bear more weight at the very end of the residual limb. Taking more weight on the end of the limb minimizes the difficult task of transferring

weight higher up on the limb and allows for more options in socket style and fit. While well-done ankle and knee disarticulations can take weight on the end, most amputation sites are simply too sensitive to support much, if any, weight on the end. As a result, many surgical and mechanical approaches have been attempted in hopes of solving this problem.

Surgeons have tried to put a patella (kneecap) on the end of a transected femur hoping that a person could kneel on his or her kneecap. In reality, however, the kneecap is not ideal for bearing weight. We actually kneel on the tendon below the kneecap. Today, this particular surgical technique, called the Getti-Stokes procedure, is only rarely performed for special needs or circumstances. The hopes for this particular reconstructive procedure never panned out, despite the initial enthusiasm.

Surgeons have also inserted mushroom-shaped implants made of rubber, silicone and metal into the end of the bone to create a broader, smoother surface that might bear weight more effectively. But problems with implant loosening, wear particles and infection dashed their hopes.

Amputation in the lower leg is different than in the thigh. There are two bones in the lower leg, the tibia and the fibula. After amputation, the cut ends of these bones may scissor toward each other, especially when weight is applied down into the socket of a prosthesis. Many people have no problems with this, but some do. To try to prevent this scissoring and to provide a surface for end weight bearing, a bone bridge can be surgically constructed with strips of periosteum (the soft outer layer surrounding bone) to cover the cut bone end and to join the two bones. Bone graft is often placed between the bones as well. This bone-bridging is one aspect of what's called an Ertl reconstruction, and it is aimed at stabilizing the tibia and fibula and creating a residual limb end capable of bearing more weight. This has worked well for some people, but, as happens many times in surgery, it has not worked for everyone. Exact data on the number of successes and the number of complications is not known.

Putting in an extra strip of periosteum or creating a bone bridge with free bone graft might increase the chance of serious bacterial infection for some people. The bone graft is essentially a scaffold for tissue to grow in. Anytime a bone graft is placed, the body needs to grow new blood vessels into the area, and the bone graft area is susceptible to infection before the body incorporates it. Some surgeons believe the increased infection rate may be high and problematic, while others do not believe a difference in infection risk exists. When talking about surgical complications, it's not always easy to get exact numbers or reach a consensus.

Other hopes for amputation healing and treating pain focus on the concept that bones are actually tubes. Transecting (cutting through) a bone, therefore, creates an open end, and many have asked whether leaving this tube open might be a source of problems and pain. Animal studies in Scandinavia have, in fact, shown that blood vessels inside the bone sometimes do grow differently if the tube is left open, rather than covered with periosteum or a plug made of bone. Some individuals have expressed hope that pain might be lessened if the end of a bone were closed or plugged. In actuality, however, these open ends heal naturally with a new surface of bone. I recently interviewed five surgeons experienced in revision amputation, and, like me, not a single one had encountered an open bone tube after the initial healing time.

While the open tube may be an issue for the first four to eight weeks following surgery, it's not really clear whether closing the bone tube with periosteum or a bone graft plug at the time of the operation actually changes the healing process or pain patterns. Again, some surgeons believe that the periosteal flap or bone graft may increase the risk of infection. Unfortunately, no final conclusions can be drawn from the animal studies, as it is very difficult to measure residual limb pain and phantom pain in animals. The second problem is that no data are available on how this affects people, and, therefore, we just don't know whether this is an issue or not. We need more research to help us understand. At this time,

therefore, saying that an open bone tube causes problems can lead to misunderstandings because that statement is simply not supported by the current scientific literature.

Our hopes for developing a procedure to improve the lives of people with limb loss are well intentioned. We want to do the right thing for every person, and we want recovery to be positive. Unfortunately, sometimes our desire to be innovative causes us to get ahead of ourselves scientifically and this can lead to hype.

The Hype

Unfortunately, at times, when conclusive scientific proof fails to confirm our hopes, some people closely involved with a new technique or invention may let their enthusiasm subconsciously bias their findings. It's human nature to want to accent the good and minimize the potential downsides of "our baby." This natural bias is present for anyone who is pushing the envelope to develop new techniques, and, thankfully, any hype is usually unintentional and not designed to deliberately mislead or be deceitful. However, enthusiasm can get ahead of science, and it's important to bear in mind that it takes time for scientific proof to confirm or disprove a theory.

Though it's the rare invention, technique or advancement that doesn't have both pluses and minuses, sometimes the promotion of techniques or devices can subtly slide from a scientific exposition to mere marketing and sales. And in the medical world, that's a dangerous transition. For instance, the concept of an internal implant to cap the bone and take the weight was developed with fantastic intent and hope. Unfortunately, many of these implants became loose and painful, and a small number became infected, leading to higher-level amputations. Some could not withstand the wear and tear over time and broke, causing problems like inflammation and wear erosion. Unnatural bursa tissue formed over the end of some implants, causing inflammation and unexpected complications. Now, it is rare to put foreign material inside an amputation because most surgeons believe the risks outweigh the successes and benefits.

Many aspects of the Ertl osteomyoplastic reconstruction are present in all good reconstructive efforts. One unique aspect for the transtibial amputee is the bone bridge, as previously mentioned. The objectives for the bone bridge are:

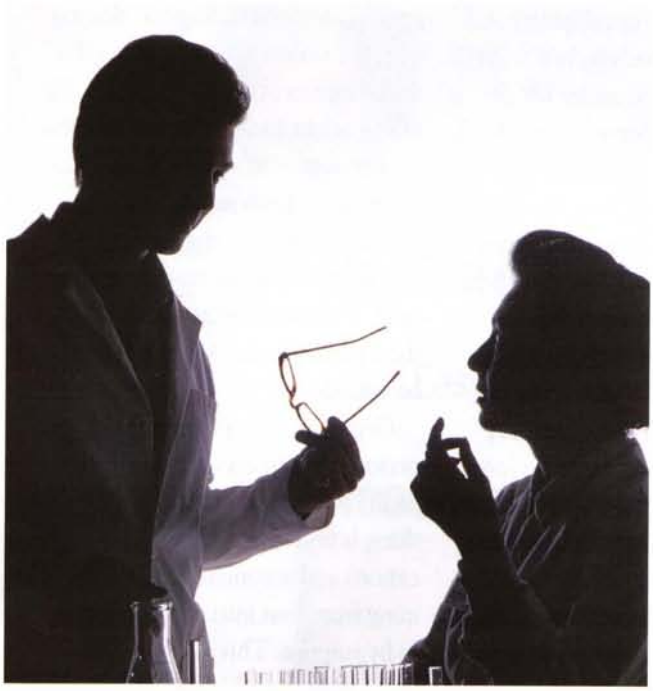
- To prevent the mechanical scissoring between the tibia and the fibula when weight is applied to the amputated leg
- To provide a broad surface of bone to improve the ability to bear weight at the end of the amputation
- To close the medullar canal within the bone to equalize or restore the pressure and circulation in the bone.

While all of these are laudable goals, scientifically measuring the benefits and possible downsides is extraordinarily difficult. Therefore, though there is currently enthusiasm by some for bone-bridging techniques, we should not lose site of the reality.

The Reality

While there are a number of anecdotal reports – personal observations based on personal experiences – about the benefits of some techniques, there is little proven, reliable scientific evidence to support all of the claims. In the scientific world, anecdotal evidence alone is not convincing. More persuasive evidence comes from studies in which individuals who have undergone a certain technique are directly compared to those who haven't. Participants are randomly assigned to equal groups so that a true comparison of the benefits and possible problems can be discerned.

To date, there have been no true scientific studies done on bone-bridging. Some of the best evidence thus far comes from a careful review at the Valley Forge Amputee Center of Vietnam War-era military veterans. Col. Paul Dougherty, MD, performed a long-term review of 72 transtibial amputees who had their treatment and care over 28 years ago. In this group, 42 individuals had received an Ertl osteomyoplastic reconstruction procedure involving the bone bridge performed as a secondary operation, and 30 had not had the bone bridge reconstruction. Careful review by Dr. Dougherty revealed that there were no scientific differences between the outcome scores of the individuals who had undergone the Ertl procedure and those who had not. Likewise, the exact rates of complications like infection and the impact on pain are anecdotal and unproven.



It is, therefore, difficult to make clear recommendations to either support or discourage this technique without further scientific evidence.

The Walter Reed Army Medical Center hosted a one-day conference last March on transtibial amputations and bone-bridging techniques where 27 scientific papers, including Dr. Dougherty's, were reviewed and discussed by a wide range of military and civilian experts in limb loss. There were differences of opinion, of course, as well as consensus on some issues. Several excellent reconstructive procedures have been successful for individuals with limb loss, and the panel of experts agreed that there is no scientific evidence that any single reconstructive amputation technique is superior to another. And it's important to note that one technique does not work for all amputees.

The group also reviewed scientific papers pertaining to the closure of the bone's medullar canal to treat pain. While animal studies showed a difference in how the blood vessels responded to amputation in and around the bone during the first four to six weeks following amputation, no scientific data were available to show what occurred in longer periods of time, such as six to 12 months. In addition, many of these short-term animal studies have often been misquoted. Therefore, we can still only speculate whether surgically closing the bone actually influences circulation, final healing and pain patterns.

As previously mentioned, my recent interviews with surgeons experienced in amputation and the reconstruction and revision of amputations revealed that none of us had ever encountered an open canal after 12 weeks. Healing of the end of the bone with bone occurs naturally, and we don't know for certain whether doing something in surgery changes the way it heals or the way the blood vessels form. In addition, there has been no human study that shows whether surgically closing the bone has an impact on pain. Again, we just do not know for certain that putting periosteum at the end of the bone during surgery changes the rate of healing, the final blood vessel circulation or any aspect of pain.

Inaccurate statements often lead to problems, and even scientific studies can be misunderstood when we rely on another person's interpretation of them, rather than reading the original study itself. It's like a game of "Telephone." Information gets passed from person to person, and then the last person relates what he's heard. When this information is compared to what the first person actually said, the differences between the original and final version of the information are significant. In science, these "telephone games" have, unfortunately, led to both misunderstandings and hype.

I believe that people want to do the right thing. People who have had a positive outcome with a certain technique are truly interested in improving results for all people with limb loss. I've had a lot of experience with a wide variety of different reconstructive techniques. I've done bone-bridging procedures on quite a number of individuals since 1989, I've

performed the Burgess posterior muscle reconstructive technique countless times, and I've also done bonecapping. I've had good results with all of these techniques but, unfortunately, I've seen complications develop from all of them as well. I believe all of these techniques warrant continued study, and, as of yet, we cannot say the Ertl is better than the Burgess or the Burgess is better than the Ertl. I believe both have a role, and one of my jobs in the future will be to help find the specific criteria for determining when one technique might be preferable to the other.

Surgeons are developing good instincts for which technique is most appropriate under which circumstance. Some surgeons can make many different techniques work well, and, unfortunately, some surgeons cannot make any technique work. These surgeons shouldn't be doing amputation surgery.

No single technique should be considered "the answer" for every patient, and reconstructive or revision surgery should be done when called for. Some people may be better candidates for a procedure after many years than they were when they had their original surgery. Some may say, "If my surgeon had only done this initially, I'd have been better off." But that simply may not be so. As time passes, the difficulty and dire nature of the original situation are not always so clearly remembered. Blame might be placed while, in reality, the surgeon should be recognized for properly understanding and dealing with the situation according to the conditions existing at the outset. He or she might have had good reasons for not doing "more" early on. In fact, the surgical team might have done an incredible job with the initial procedures, given the circumstances at that time. If circumstances change later, then perhaps other techniques should be considered.

Coping is an ongoing process. A person who suffers an injury at 20 might recover and think that everything is fine. Then, at age 50, complications and secondary conditions stemming from that initial injury might set in by surprise. This does not necessarily mean that something was overlooked and could have been remedied 30 years earlier because complications can develop over years. Now, however, it might be time to look at other options.

A single answer that would fit every individual sounds wonderful, doesn't it? Unfortunately, the reality is that if something sounds too good to be true, then it probably is. As *Newsweek* magazine noted in its May 19, 2003, issue, "Even the giddiest scientist knows that the journey from lab to clinic is long and unpredictable."

Surgeons, patients and families need to identify and discuss both their immediate and secondary goals. Though there could be good reasons, such as a high risk of infection, for not using an advanced reconstructive technique during the initial surgery, the person might later be a good candidate for secondary reconstruction. Amputation needs to be done reconstructively and with a focus on long-term function, but there are occasions where not everything should be done at the first surgery. When it comes to reconstructive amputation techniques, timing is everything. ■