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Knee Osteoarthritis: The Emerging Role of Physical Therapy

ABSTRACT & COMMENTARY

Synopsis: *Using a randomized trial, an eight-week course of manual therapy and exercise improved walking distances and WOMAC scores at four and eight weeks. These differences continued at one year, by which time 20% of the placebo group (subtherapeutic ultrasound) compared to only 5% of patients treated with rehabilitation had undergone total knee replacement.*

Source: Deyle GD, et al. Effectiveness of manual physical therapy and exercise in osteoarthritis of the knee. A randomized, controlled trial. *Ann Intern Med* 2000;132:173-181.

Knee osteoarthritis (koa) commonly affects more than 10% of adults, including 33% of patients between the ages of 63 and 94. In a recent review, more than 90% of KOA was treated successfully with nonoperative means, avoiding surgery altogether.[1] Many medical options exist in the treatment of KOA, including acetaminophen, nonsteroidal anti-inflammatory agents (NSAIDs), cortisone and hyaluronan injections, and alternatives such as glucosamine and chondroitin sulfate. Use of NSAIDs is commonplace, as are the risks of gastrointestinal (GI) complications in the population older than 60 years of age. Mechanical changes to treat KOA include shoe wear modifications, unloader bracing, and weight loss. Physical therapy has also been considered to be an effective means to treat KOA, including active and passive range of motion exercises, fitness walking, aerobic exercise, and strength training. Deyle and colleagues examined the effectiveness of manual physical therapy and exercise against placebo in the conservative management of KOA.

In an institutional review board (IRB) approved study, Deyle et al created two randomization arms. Forty-two patients (average age, 60 ± 10 years) were assigned to the treatment group and 41 patients (average age, 62 ± 10 years) received a placebo. Demographics including gender were similar for both groups. Exclusion criteria involved having received a cortisone injection within 30 days and

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patients were instructed to continue taking routine prescription or over-the-counter NSAIDs. Treatment patients received manual physical therapy and supervised exercise. Placebo patients received subtherapeutic ultrasound. Radiographs were obtained on all patients and were graded by a radiologist. Dependent variables included the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score and a timed six-minute walk test. Manual therapy treatment techniques included passive physiologic and accessory joint movements, muscle stretching, and soft tissue mobilization. Other involved joints, including the lumbar spine, hip, and ankle, were also treated if symptomatic. Progressive knee exercises including strength training were performed over eight weeks. Patients exercised in a painless or minimally painful manner. Exercises were decreased with joint irritation. The placebo group received 10 minutes of ultrasound (subtherapeutic) with similar subjective and objective hands-on evaluation during treatment. The treatment group required an extra 30-45 minutes over placebo to complete each treatment. A home program with an instruction sheet was used for the treatment group during off days. Eight clinic visits (weekly) were performed for both treatment and control groups.

Of the 83 patients enrolled, 69 completed all clinic visits and testing at four weeks, eight weeks, and one year. The average timed walk was better for the treatment group (4 weeks: 82 m better, 8 weeks: 78 m better, $P < 0.05$) as compared to control. Similarly, WOMAC scores were 416 mm better at four weeks and 472 mm better at eight weeks ($P < 0.05$) as compared to placebo. At one year, 20% of the placebo group had received a total knee replacement (TKR) vs. 5% of the treatment group ($P < 0.039$). The placebo group also received more cortisone injections. Walking and WOMAC scores persisted at one year in those patients not undergoing a TKR or injection.

COMMENT BY ROBERT C. SCHENCK, Jr., MD

The benefits of physical therapy have been shown in the elderly population in previous studies. In this randomized trial Deyle et al have now shown effectiveness in a general population of patients with KOA. Most impressive is the significant decrease in total joint surgery required in the treatment group. As in any treatment plan, reproducibility is key. Deyle et al include exercise descriptions and tables for the use of their program outside San Antonio, Texas. When applying such a treatment plan, the clinician should educate the treating therapist (and in this reviewer's case vice versa) on the program and study. (Single reprints can be obtained via the Internet at gail.deyle@amedd.army.mil.) The combination of clinic- and home-based physical therapy should not be underestimated. The use of patient education, home use materials, and exercise sheets allow for progression of rehabilitation through the week and not just during the single clinic visit. This home-based component may have contributed to the 20-30% improvement rate seen after only two to three visits. Home-based therapy programs have great benefit to patients, including convenience and safety.[2]

Unfortunately, Deyle et al did not include a cost analysis of their treatment. Depending upon the clinic, physical therapy visits can cost from $50-$150 per visit, not including the initial evaluation. The use of NSAIDs was not controlled and use of a standard medication could be a future consideration for such studies. Furthermore, the cost of both prescription NSAIDs and the cost of treating NSAID complications are also significant. The comparison of two treatment arms, NSAID vs. PT vs. placebo, is an excellent future research topic. The importance of time spent between therapist and patient was acknowledged as different. Could time alone be partially responsible for the improved success? I admit it is unlikely, but time spent with patients is a confusing variable. Lastly, the inability to double blind the study raises questions that in reality can't be answered due to the nature of the process.

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The conservative management of KOA has many angles and avenues for success. Frequently, patients come to the clinician having already tried alternatives (glucosamine/chondroitin sulfate) and some form of over-the-counter NSAIDs. Prescription NSAIDs (especially new COX-2 inhibitors) also have a place in the treatment of OA. Nonetheless, the functional focus (increasing strength, increasing range of motion) of a well-defined "clinic-based/home-extended" physical therapy program is a significant finding by Deyle et al. The actual decrease in total joint arthroplasty in the treatment group as compared to placebo gives concrete reasons for including physical therapy programs in the conservative management of KOA. ❖

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Endurance Sports After Total Knee Replacement: A Biomechanical Investigation

ABSTRACT & COMMENTARY

Synopsis: *Cycling and power walking appear to be acceptable and preferable to running and downhill walking in patients following total knee replacement.*

Source: Kuster MS, et al. Endurance sports after total knee replacement: A biomechanical investigation. *Med Sci Sports Exerc* 2000;32:721-724.

The majority of investigations on the effect of physical activity on joint stresses following hip and knee arthroplasty have considered walking on level ground. Kuster and colleagues sought to determine the contact stress distribution and contact area of three different knee joint designs during four common recreational activities. The simulated recreational activities included cycling, power walking, hiking, and jogging. The total knee designs consisted of a flat, curved, and mobile bearing tibial inlay. For all designs, a medium-sized prosthesis was used. All designs were cemented into a metal block and mounted on a material testing system. Pressure-sensitive films were inserted between the femoral component and the inlay, scanned, and analyzed using an image analysis system to obtain total contact area and the area overloaded beyond the yield point of the polyethylene. The test positions simulated power walking (4 × BW at 20° simulated knee flexion), downhill walking (8 × BW at 40° flexion), jogging (9 × BW at 50° flexion), and cycling (1.2 × BW at 80° flexion).

Results demonstrated that during cycling, the area of stress levels above the yield point of polyethylene was less than 15 mm^2 for each design. During power walking, the mobile design showed no overloaded area, whereas it was less than 50 mm^2 for the flat and curved designs. During downhill walking and jogging, more than 140 mm^2 was overloaded for each of the three designs.

COMMENT BY DAVID H. PERRIN, PhD, ATC

The benefits of physical activity are well known, and it behooves surgeons and therapists to recommend modifications so that patients undergoing arthroplasty of the hip or knee can continue to experience the benefits of regular exercise. Kuster et al surmise that it is important to distinguish between suitable activities after arthroplasty because of different implant geometries, and that many total knee replacements result in a mismatch between the femoral and tibial radius with high peak pressures on the polyethylene inlay. These high pressures could lead to increased wear and resultant destruction of the inlay. As such, they emphasize that both the load and knee flexion angle of the peak load should be considered when recommending physical activities. Kuster et al conclude that 40-70% of the overall contact area was stressed above the yield point during jogging and downhill walking, and that these activities may endanger the inlay of most total knee prostheses. Power walking produced overload areas three times smaller than jogging or downhill walking, and they thus recommend that power walking can be permitted. They further reported that the tibiofemoral load was small during cycling, and that cycling can be performed after total knee replacement, although patients should place the bicycle seat as high as possible. They recommend an optimal exercise protocol based on these findings that alternates between cycling and power walking following total knee replacement, because these activities load different parts of the tibial inlay and thus ensure a more even wear pattern.

The obvious limitation of this study was that the joint stresses during the physical activities of power walking, jogging, downhill walking, and cycling were based on a simulated biomechanical model. Nevertheless, the study

reminds us of the importance of modifying and recommending activities that reduce the stress to joints following arthroplasty so that patients can experience the benefits of physical activity. Further research models should determine joint stresses during a variety of physical activities following arthroplasty and other surgical and bracing procedures for lower extremity degenerative joint conditions. ❖

What Do I Do When I Drop the Graft?

ABSTRACT & COMMENTARY

Synopsis: *Pulsatile lavage with three liters of 2% chlorhexidine solution followed by a saline rinse was found to effectively decontaminate bone-tendon allografts whereas other techniques did not.*

Source: Burd T, et al. The effects of chlorhexidine irrigation solution on contaminated bone-tendon allografts. *Am J Sports Med* 2000;28:241-244.

As the use of autogenous and allogenic tissues in orthopaedic reconstruction procedures becomes more common, there needs to be an established method for disinfecting a graft that has been inadvertently contaminated. This paper sought to determine the most expedient and effective method for disinfecting human bone-tendon allografts.

Burd and associates from the University of Missouri thoroughly addressed this issue with a three-part experimental protocol. The first part involved both beef muscle and human cadaveric tensor fasciae latae tissue samples. Soft tissue samples were used because these are more subject to contamination and more difficult to sterilize. Part 1 was performed as a screening method to select the most promising method of sterilization, which was further tested in parts 2 and 3 of the study. The tissues were all contaminated with a carefully standardized inoculum consisting of four different bacteria: *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Pseudomonas aeruginosa*, and *Klebsiella pneumoniae*. These bacteria were selected based on their high virulence as well as the fact that these are common bacteria for orthopaedic infections or are found on an operating room floor. To simulate the scenario of dropping a graft on the floor, the bacterial inoculum was allowed to incubate at room temperature for one minute, following which the tissues were swished in sterile saline for about two minutes until the power irrigation equipment was assembled.

At that point several solutions as well as methods of delivery were assessed. These included 0.05% Castile soap and/or 0.03% benzalkonium chloride, triple-antibiotic solution (gentamicin 0.1%, clindamycin 0.1%, and polymixin 0.05%), or 4% chlorhexidine gluconate, each irrigated with pulsatile lavage equipment with a three-liter or one-liter volume. Additionally, successive 30-minute soaks with the combination of 4% chlorhexidine and the triple-antibiotic bath were tested. Normal saline was used as a control.

Burd et al found that all solutions used with just one liter of volume had positive cultures. The only successful decontaminations were with the three liters of power irrigation with chlorhexidine gluconate or with the successive 30-minute soaks of chlorhexidine and the triple-antibiotic solution. Based upon these findings, Burd et al then assessed varying concentrations of chlorhexidine from 0.05% to 4% and found that the 2% solution was as effective as 4% and achieved 100% decontamination.

Lastly, fresh human Achilles bone-tendon allografts were inoculated and then tested following treatment with three liters of a 2% chlorhexidine power wash followed by a saline rinse. Ten out of 10 allografts were effectively decontaminated. All of the control specimens produced positive cultures for this as well as the other parts of the study, confirming the sensitivity of the method for detecting the presence of bacteria, using a combination of broth and plate culturing.

COMMENT BY DAVID R. DIDUCH, MS, MD

Inadvertently dropping a graft in the operating room is considered a disaster. The options at that point are limited: 1) harvest a new graft from the opposite knee or a different source, 2) use a new allograft, or 3) somehow disinfect the contaminated graft. Harvesting a new graft from the contralateral knee or a new location results in additional morbidity and may alter the perioperative rehabilitation. There may be medical-legal concerns regarding informed consent for taking an additional graft as well as changing to an allograft intraoperatively. Ideally, there would be a method to predictably decontaminate and still use the graft that had been harvested. This paper by Burd et al is a major step toward establishing such a method. Their experimental protocol was carefully planned and effectively addressed the question. They had adequate numbers of specimens involving both animal and human tissue, and methods to assess the presence of bacteria were appropriately sensitive. Sample numbers were sufficient to achieve statistical significance. This is a strong paper with excellent clinical implications.

In summary, Burd et al determined that chlorhexidine was more effective than the other solutions at decontaminating the grafts. Furthermore, they established that a power wash with three liters of chlorhexidine effectively decontaminated the graft. This can be done in 10 to 12 minutes. This is a vast improvement over the previously established method by Goebel et al, which prescribed successive 30-minute washes of chlorhexidine followed by a triple-antibiotic bath.[1] Sixty minutes of operating room time, anesthesia time, and potential tourniquet time is dramatically different than a 10- to 12-minute power wash. There appeared to be no advantage to long-term soaks in this study over the power wash.

A similar article in the current issue of *Arthroscopy* also found 4% chlorhexidine gluconate to be superior to all other solutions tested.[2] That study by Molina et al only soaked the graft for 90 seconds; however, contamination occurred by dropping the graft on the floor for 15 seconds as opposed to direct inoculation with bacterial cultures for one minute in Burd et al's study. It would seem the direct inoculation provides a more difficult challenge to graft sterilization given that only 58% of control, untreated grafts cultured positive after dropping on the floor. Interestingly, in all of these studies, treatment with povidone-iodine solution, which is most commonly used for surgical preps, was ineffective at graft sterilization.

Burd et al stressed that we have not determined the biological effects of using chlorhexidine on human tissues and whether this will alter the mechanical properties of a graft. Because of this, they do not advocate using this technique yet in the clinical setting. They are planning further experiments to assess the mechanical effects on the graft as well as any cellular toxicity. They do recommend rinsing the graft with saline using the same power wash conditions to help remove residual chlorhexidine. Until these studies are available it would be a clinician's preference as to whether to put this current information to use should the unanticipated disaster of a graft drop occur. Burd et al do mention that intra-articular lavage with chlorhexidine does produce untoward effects on the synovium and articular surfaces in horses, supporting the notion of thoroughly washing the graft after the chlorhexidine treatment.

The standards in place for disinfecting operating room floors generally yield a low bacterial count on a floor that should be below the minimum number of bacteria required to produce infection. However, the devascularized nature of an allograft or even removed autograft reduces the bacterial contamination level required to produce an infection to four times less. As few as 100 colony-forming units (CFU) of *S. aureus* on allografts have resulted in an infection rate of 50% of allografts implanted.[3]

As such, an effective method to decontaminate a graft is essential before we consider replacing it in the knee. Burd et al are to be congratulated on their research protocol, and further studies will help us with decision-making in this disturbing scenario which we all hope never to encounter. ❖

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3. Cordero J, et al. Influences of bacterial strains on bone infection. *J Orthop Res* 1996;14:663-667.

Meniscal Allograft Follow-up

ABSTRACT & COMMENTARY

Synopsis: *A short- to intermediate-term follow-up of 23 meniscal transplants. All patients received nonirradiated, cryopreserved allograft menisci (CryoLife) sized based on plain radiographs with correction for magnification. Bone plugs were used to secure the meniscal horns for both medial (11) and lateral (12) grafts. An arthroscopic technique that Stollsteimer and colleagues previously published was used in all cases.*

Source: Stollsteimer GT, et al. Meniscal allograft transplantation: A 1- to 5-year follow-up of 22 patients. *Arthroscopy* 2000;16(4):343-347.

All patients were evaluated clinically at one to five years (average 40 months) postoperatively, and 12 patients underwent magnetic resonance imaging (MRI) scans of both knees. At follow-up, 18 of 23 patients had improvement in pain following the procedure. Lysholm scores improved from an average of 47.2 to 75.6, but IKDC demonstrated normal or nearly normal scores in only 13 of 23 knees. Of most significance, however, was the fact that MRI demonstrated significant shrinkage of the transplanted menisci. The average size of the transplanted meniscus was just 62% (range, 31-100%) of that in the opposite knee.

COMMENT BY MARK MILLER, MD

Although this article suffers from lack of long-term follow-up and did not include MRIs of all knees, it does

highlight some important concerns regarding meniscal transplantation. As Stollsteimer and colleagues point out, meniscal transplantation is an extremely challenging (and costly) procedure. Before it is universally accepted, we have an obligation to ensure that it will be successful. Although most patients in this study improved clinically, the success of this operation does not come close to the improvement in scores from anterior cruciate ligament (ACL) reconstruction, for example. Therefore, it is probably best considered a salvage procedure that is perhaps still investigational.

Of most concern in this report is the shrinkage of grafts on MRI evaluation. Several previous anecdotal reports of graft shrinkage are substantiated by this report, and this mandates further study of this important issue. Meniscal shrinkage is, at best, difficult to assess arthroscopically. Stollsteimer et al's assessment of shrinkage on a volumetric basis with MRI is probably more reasonable. But what does it mean? The question that remains is whether the transplanted meniscus functions like a native meniscus. Perhaps weight-bearing or dynamic MRIs will give us further clues in the future. Longer-term follow-up studies may also give us some idea if transplantation delays the onset of degenerative arthritis in these patients. We should proceed with caution until more is known about the long-term efficacy of meniscal transplantation. ❖

Why Does the MCL Repair so Well After Injury, While the ACL and PCL do Not?

ABSTRACT & COMMENTARY

Synopsis: *The ACL and PCL synthesize larger amounts of nitric oxide and synthesize less collagen and proteoglycans than the MCL.*

Source: Cao M, et al. Does nitric oxide help explain the differential healing capacity of the anterior cruciate, posterior cruciate, and medial collateral ligaments? *Am J Sports Med* 2000;28:176-182.

This is a basic science study comparing the ability of the New Zealand white rabbit medial collateral ligament (MCL), anterior cruciate ligament (ACL), and posterior cruciate ligament (PCL) to produce nitric oxide (NO). Ligaments were placed into tissue or cell culture, and nitric oxide, collagen, and proteoglycan synthesis were compared. Cao and colleagues were not blinded to the ligament when recording the results.

The results indicate that the ACL and PCL spontaneously synthesize larger amounts of NO and synthesize less collagen and proteoglycans than the MCL. Furthermore, when stimulated with the inflammatory cytokine interleukin-1, ACL and PCL tissue produced much higher amounts of NO than did MCL tissue. When exogenous NO was applied to these tissues, it had a profound inhibitory effect on collagen synthesis by ACL and PCL tissues, while producing little effect on MCL collagen production. Lastly, endogenous NO inhibited collagen and proteoglycan production by ACL and PCL tissues, but had little effect on the MCL.

COMMENT BY JAMES R. SLAUTERBECK, MD

So, why do the ACL and PCL heal so poorly and the MCL so well? Many theories have been put forth that typically are divided between intrinsic and extrinsic explanations. The extrinsic explanations define that the environment immediately surrounding the ligament is different and is responsible for the variable reparative response. For example, the MCL is a capsular-type ligament with a better blood supply and outside the synovial fluid of the knee, which allows clot formation and a better healing environment. The other theory relies on the concept that the ACL, PCL, and MCL have different intrinsic repair potentials. That is, the cells within each ligament differ ultrastructually, morphologically, and physiologically in their response to tissue injury and repair.

This study looks at NO production differences between the ligaments. In a prior study, Cao et al found that NO in articular chondrocytes strongly inhibits collagen and proteoglycan synthesis. Additionally, it appears that NO inhibits healing by blocking matrix synthesis, prolonging the early stages of inflammation and blocking cell division. Therefore, a difference in the production or response to the NO between ligaments may provide an explanation for differential healing capabilities.

This paper identified a difference in the production of NO occurring between ACL, PCL, and MCL in tissue and cell culture. Both cell and tissue culture were used to verify that the NO synthesis was not a response to the preparation of the cell culture but actually a response of the cells to known NO-inducing and blocking agents. Both the cell and tissue culture responded appropriately, adding validity to their results. The cruciate ligaments appear to produce higher levels of NO de novo as well as in response to inflammatory cytokines, which would be released in response to injury.

Ultrastructural differences between similar tissues play an important role in the ability of that tissue to repair. Although not much is known about all the effects

of NO on tissues, it looks promising that the production of NO alters tissue's ability to respond to injury. Increased NO appears to inhibit collagen and proteoglycan synthesis, which would be essential to ligament healing. This paper adds to our knowledge base and proposes a new idea that NO production decreases the ability of ligament to heal. Therapeutically, a pharmacological agent that specifically inhibits NO production may help tissues heal faster and may someday help us to better repair injured ligaments. ❖

How Muscle Forces Contribute to ACL Tears

ABSTRACT & COMMENTARY

Synopsis: *An imbalance of muscle activity during footstrike may be responsible for the force that actually causes the ACL to tear. This supports the potential for neuromuscular training to decrease the incidence of ligament injuries in athletes.*

Source: Colby S, et al. Electromyographic and kinematic analysis of cutting maneuvers: Implications for anterior cruciate ligament injury. *Am J Sports Med* 2000;28:234-240.

Anterior cruciate ligament (acl) injuries have been estimated to occur in one out of every 3000 individuals. However, the majority of these injuries occur in individuals between the ages of 15 and 45, an age group encompassing approximately 47% of the population. With this new denominator, the incidence of injury in the susceptible population becomes one per 1750 individuals.[1] Despite this frequency and despite the fact that the immediate and long-term consequences of ACL injuries are significant, the exact mechanism of this injury is yet unknown.

Colby and associates emphasize that we do know that these injuries occur "near footstrike, when the quadriceps muscles are eccentrically activated to resist flexion." Moreover, they occur during deceleration or while changing directions, as in cutting and landing. Colby et al theorize that internal forces generated by the leg muscles must be involved in creating sufficient force to tear the ACL during these maneuvers, since inertial forces involved in these activities (decelerating, cutting, and landing) would result in an anterior force on the femur and a posterior force on the tibia (i.e., forces that might injure the posterior cruciate ligament [PCL] but should not injure the ACL).

Therefore, to better understand muscle forces on the knee at footstrike, Colby et al evaluated electromyographic activity using surface electrodes of the vastus lateralis, vastus medialis, rectus femoris, biceps femoris, and medial hamstrings. Fifteen healthy collegiate and recreational athletes were assessed at various flexion angles while performing ACL "at-risk" activities of cross-cutting, sidestep cutting, stopping, and landing. In their study, footstrike of the athlete occurred at an average of 22° of knee flexion during all maneuvers and, just before footstrike, a high-level quadriceps muscle activation occurred. This activation peaked in mid-eccentric motion. During this same time period, the hamstring muscle activation was suboptimal.

Hence, from Colby et al's data it would appear that on or about footstrike, the high quadriceps forces achieved by eccentric contraction coupled with the submaximum hamstring muscle activity could result in sufficient anterior displacement of the tibia on the femur to injure the ACL.

COMMENT BY LETHA Y. GRIFFIN, MD, PhD

Colby et al add another piece to the puzzle of the mechanism of noncontact ACL injuries. Environmental, anatomic, hormonal, and neuromuscular factors have all been implicated as possible etiologic factors of noncontact ACL injuries. At present, alteration of neuromuscular risk factors appears to hold the most promise as the basis for formulating prevention strategies.

The fact that women land from a free fall, pivot, and cut all in a more upright position (i.e., less hip and knee flexion) than men may contribute to their higher rate of noncontact ACL injuries when compared with equally trained and conditioned males. It does appear, from this study and others, that the quadriceps mechanism can produce sufficient force to tear the ACL at low levels of knee flexion. Therefore, it would seem prudent to institute as part of preseason conditioning in all athletes, especially women athletes, drills designed not only to strengthen the hamstrings but also to teach athletes to land from jumps, to cut, and to pivot with the hip and knee flexed, and by so doing, minimize strain on the ACL.

Hewett et al, in an article reviewed in the March 2000 issue of *Sports Medicine Reports*, showed that such a program for neuromuscular training for female athletes reduced their incidence of ACL tears to a rate equivalent to that of male athletes.[2] More prospective studies like this would need to be done to verify the hypothesis that neuromuscular retraining to increase hamstring and quadriceps co-contraction can decrease the incidence of noncontact ACL injuries and therefore are worthwhile prevention techniques. ❖

References

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CME Questions

1. Following total knee replacement, the most desirable form of exercise with the most equal distribution of joint stress appears to be:

a. hiking that includes downhill walking.
b. a combination of cycling and power walking.
c. power walking.
d. jogging.
e. cycling.

2. In treating knee osteoarthritis, a physical therapy program was found to:

a. not affect patient outcome.
b. be more expensive than the group treated with NSAIDs.
c. be less effective than treatment with ultrasound.
d. reduce the need for total knee replacement at one year.
e. show only short-term benefit.

3. The most effective and expeditious way to decontaminate a graft that has been dropped is:

a. use of benzalkonium chloride and Castile soap.
b. 1 L of 4% chlorhexidine wash.
c. 30-minute triple-antibiotic bath soak.
d. 3 L of 2% chlorhexidine power wash.

4. Nitric oxide synthesis is proposed to inhibit healing by:

a. inhibiting collagen synthesis.
b. inhibiting proteoglycan synthesis.
c. prolonging the inflammatory phase of healing.
d. All of the above

5. ACL noncontact injuries:

a. occur primarily in the elderly.
b. frequently occur during deceleration or while changing directions.
c. have a higher rate of occurrence in men soccer players than women.
d. have not been found to be associated with any significant long-term sequelae.
e. are frequently caused by wearing too large of a shoe.

6. What is the average size of nonirradiated, cryopreserved allograft meniscal transplants (compared to the opposite knee) on one- to five-year follow-up MRIs?

a. 125%
b. 100%
c. 95%
d. 62%

In Future Issues:

Beware of the Bone Bruise
ACL Reconstruction in the Skeletally Immature Athlete