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How Safe is Pole Vaulting?

ABSTRACT & COMMENTARY

Synopsis: *Devastating injuries from pole vaulting may be prevented by attention to equipment, weight restrictions, and padding around the landing area.*

Source: Boden BP, et al. Catastrophic injuries in pole-vaulters. *Am J Sports Med.* 2001;29(1):50-54.

This is a retrospective review of catastrophic injury in pole-vaulters collected by the National Center for Catastrophic Sports Injury Research from 1982 to 1998. The purpose was to identify catastrophic pole-vaulting injuries and to propose prevention plans. High schools, colleges, universities, and news-clipping services were contacted yearly to identify any catastrophic events. When possible, the athlete, athlete's family, coaches, or athletic directors were contacted to obtain details regarding the accident, facility, landing area, and weather conditions. Catastrophic injuries were not specifically defined but included 31 head injuries and 1 thoracic spine fracture resulting in paraplegia. The accidents resulted in death 50% of the time and in permanent disability 20% of the time. All injuries were in male athletes in whom 53% partially landed on the pad with the head impacting the ground, 16% completely missed the landing pad, and 25% landed in the vaulting box.

COMMENT BY JAMES R. SLAUTERBECK, MD

Catastrophic injuries occurring in sporting events, especially in amateur athletes, are devastating occurrences that need our attention as team physicians. Although post-injury medical management is rewarding in many cases, the treatment affects relatively few athletes whereas injury prevention may affect many more. Two years ago, a female pole-vaulter from a local college sustained a traumatic spondylolisthesis at an away meet and had fixation by the home-team physician. Since this occurrence, I watch the pole-vaulting events from a much different perspective and have often wondered how many athletes get seriously injured during the event.

Prior to this review, I was unaware of the rule changes making the sport safer. As a team physician for several track and field teams, I now want to ensure the safety of the pole-vaulting athletes. In 1987, the National Federation of State High School Association's Track and Field Rules committee mandated increased padding around the vault box. In 1995, the pole-vaulter's weight was mandated to be at or below the pole's recommended weight to increase the control of the pole. Finally, all hard and unyielding surfaces surrounding the pad need to be cushioned. The value of headgear to protect the athlete is currently being debated. It is disturbing to read the reports identifying the number of athletes seriously injured from just missing or partially hitting the mat upon landing. I strongly support increasing the size of the mats and softening the ground around the mats. Maybe a sandpit surrounding the mat would decrease injury even more.

This is an important retrospective study noting catastrophic injury occurrences in pole-vaulters. We need to continue to find ways to increase the safety for the athlete. Better coaching, more pads, and softer areas outside of the mat certainly will help. If you currently provide care for track athletes, check the pit and surrounding areas and make sure the landing area is as safe as possible. ❖

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Runners Rejoice!

ABSTRACT & COMMENTARY

Synopsis: *Former Olympic runners were not at increased risk of either hip or knee arthritis as compared to former team sports athletes or controls.*

Source: Kettunen JA, et al. Lower-limb function among former elite male athletes. *Am J Sports Med.* 2001;29(1):2-8.

This is a retrospective review to investigate lower extremity disability of former elite athletes. In 1995, a questionnaire was sent to 1321 former Finland Olympic track and field, power, and team sport athletes from 1920 through 1965. The athletes were grouped by activity level and by sport played. The control group was age-matched individuals determined to be healthy at the time of their military physical at age 20. The questionnaire was returned by 75% of the athletes and 71% of the controls. All participants were grouped by occupation to determine if an association between occupation and disability existed. The purpose of the study was to determine if an elite running athlete is at greater risk of developing lower extremity disability later in life than other athletes or the general population.

The results showed that hip and knee disability were more common in the elderly than in the young, and those with greater body mass were at greater risk for knee disability. Additionally, those with a history of prior knee ligament injury, meniscus injury, or with an occupation like a farmer or a skilled worker had greater lower extremity disability than controls. Based on the questionnaire, all age-adjusted former athletes had less hip disability than the controls, but former team sport athletes had greater knee disability than all others. Physician diagnosed knee arthritis was higher in team sport athletes, but hip arthritis was diagnosed similarly in all groups.

■ COMMENT BY JAMES R. SLAUTERBECK, MD

So is the running athlete at greater risk for lower extremity disability? I often get asked this question in one form or another in my sports medicine clinic. I traditionally have responded by saying, "If your knee has never been seriously injured, or if you have not had knee surgery, you can probably run guilt free. However, if your knee swells or is painful, you should be suspicious of internal damage and consider cross training on a bike or in the swimming pool."

Several strengths are present in this article. The study defines a specific group of elite athletes and stratifies the athletes by sport, injury, and disability. Additionally, age, body mass index, and occupation were recorded and adjusted because these contribute to lower extremity disability. Finally, the questionnaire was returned by a high number of the athletes and controls (75% of the athletes and 71% of the controls).

Some shortcomings are present in addition to those inherent to a retrospective study. Although the control group was healthy at the time of their military physical, I am unsure if they participated in running or team sports later in life. Possibly a better control group would be nonsmoking, normal weight, nonathletic males and females determined by a questionnaire. Additionally, I am unsure if the questioner was validated.

In my opinion, the strengths exceed the shortcomings. This article reports on team and individual Olympic athletes from one country to determine if athletes differ in risk for lower extremity disability when compared to controls. The conclusions will be of great interest to many concerned athletes. We can comfortably tell our runners that they may run and remain at low risk for knee and hip disability as long as they remain uninjured. Additionally, we can counsel team sport participants that they are at greater risk for knee disability when compared to individual sport participants.

So does this study affect my patient care? I believe so. Runners are often a well-read group of athletes and can be difficult to treat and counsel. This paper is readable by athletes and physicians and supports ones' desire to run but warns of the risk of running after significant knee injury. ❖

Therapeutic Magnets and Tissue Temperature

ABSTRACT & COMMENTARY

Synopsis: *Flexible therapeutic magnets did not affect skin or deep tissue temperatures.*

Source: Sweeney KB, et al. Therapeutic magnets do not affect tissue temperatures. *Journal of Athletic Training.* 2001;36(1):27-31.

Competitive and recreational athletes use therapeutic magnets to treat the pain arising from all types of musculoskeletal injuries. Sweeney and associates sought to determine if the application of therapeutic magnets increased skin and deep tissue temperatures in comparison to sham and control treatments. The basis for the study was the suggestion that therapeutic magnets increase blood flow by increasing tissue temperature.

Subjects for the study were 13 healthy university students. The treatments included the application of a single 5×11 commercially available magnet, a silicone rubber and cork sham treatment identical in size, thickness, and mass to the magnet, and a control consisting of temperature measurement only. Quadriceps tissue temperatures were measured 1 cm below the fat layer with implantable fine-wire thermocouples interfaced with a 16-channel electronic thermometer. Skin and ambient temperatures were measured with copper/constantan thermocouples. Temperature measurements were taken every 30 seconds for 60 minutes. The skin and intramuscular temperatures under the 3 treatment conditions were analyzed at 0, 20, 40, and 60 minute time points.

The magnet used in this study was advertised as having field strength of 700 G (0.07 T). To confirm this field strength, Sweeney et al used a gauss meter at arbitrarily selected points on the treatment surface to measure magnet field strength and uniformity.

Sweeney et al found no differences in skin or intramuscular temperatures across the 3 treatments at any time. Intramuscular and skin temperatures had a tendency to rise slightly for both the magnet and sham groups over time. Sweeney et al attributed these clinically insignificant increases to the insulating properties of the magnet and sham treatments. The field strength of the magnet ranged from 6 G to 537 G.

COMMENT BY DAVID H. PERRIN, PhD, ATC

As with many alternative therapies, little scientific evidence exists to explain or document efficacy of treatment. It has been estimated that more than $500 million has been spent on magnet products in 1 year alone. Therapeutic magnets are purported to increase blood flow from the Hall effect, which causes charged particles to accumulate with like charges in the presence of a magnetic field. Manufacturers suggest the resistance of these particles to accumulate against their normal direction of flow produces heat that in turn results in blood vessel dilation.

Sweeney et al found no difference in intramuscular or skin temperatures among the magnet, sham, and control treatments. Although the design of this study did not measure blood flow, one would expect an increase in tissue temperature in the presence of increased blood flow. It would be interesting to measure blood flow in future studies on the efficacy of magnet therapy.

Magnet therapy has also been associated with reductions in pain and improvements in range of motion and strength. As with tissue temperature, the scientific evidence for these claims is scant. Borsa and Liggett examined the effects of magnets on pain, range of motion, and strength after muscle micro-injury and also failed to find a therapeutic effect.[1]

This study also found that the field strength of the magnet was variable and did not attain advertised levels. It is possible that the lower levels of field strength might have accounted for the failure of the magnet to increase tissue temperature. However, this would seem unlikely as no trends toward increased temperatures from the magnet treatment in comparison to the sham treatment were observed. Continued study and oversight of the purported field strength and treatment efficacy of magnet therapy by the Food and Drug Administration appears to be indicated. ❖

Reference

1. Borsa PA, Liggett CL. Flexible magnets are not effective in decreasing pain perception and recovery time after muscle microinjury. *Journal of Athletic Training.* 1998;33:150-155.

Tissue Engineering: Making a Meniscus

ABSTRACT & COMMENTARY

Synopsis: *An animal model using a collagen scaffold derived from porcine small intestine produced gross and histologic meniscal regeneration in the rabbit model.*

Source: Gastel JA, et al. Meniscal tissue regeneration using a collagenous biomaterial derived from porcine small intestine submucosa. *Arthroscopy.* 2001;17(2):151-159.

This pilot study evaluated the meniscal regeneration potential of a collagen scaffold derived from porcine small intestine submucosa (SIS). Twelve animals had a 3 mm wedge defect from the central third of the lateral meniscus treated with a patch of SIS. The opposite limb served as the control with an identical empty defect created in the lateral meniscus. Four animals were euthanized at 4, 12, and 24 weeks. At each time period, 2 animals were studied with microscopic histology and the remainder evaluated only grossly.

Based on gross evaluation, the control group had less densely opaque tissue compared with the SIS side. Both groups showed significant signs of healing on histological evaluation at 6 months. At this late time period, remnants of the graft were no longer identifiable in the healing tissue. Furthermore, the experimental specimens showed more organized tissue resembling that of the native meniscus.

COMMENT BY ROBERT C. SCHENCK, Jr., MD

Tissue engineering in orthopaedic surgery is taking the specialty beyond the days of repair to that of tissue regeneration, and the orthopaedic surgeon must become familiar with these concepts. Regeneration involves the creation of identical tissue to that lost or injured and can be contrasted to repair, which restores the damaged area with a functional but different tissue. It is in regeneration that tissue engineering is directed and involves the manipulation of connective tissues through the use of 3 components: cells, scaffolds, and growth factors. The term "cell" in most tissue engineering recipes is usually the mesenchymal stem cell (MSC). Despite differing names (connective tissue progenitor cells, colony forming units, etc), MSCs involve a true progenitor cell that has limitless self renewal and can differentiate down multiple pathways (ie, to become bone, cartilage, tendon, meniscus, or ligament).[1] The greatest source for MSCs is from bone marrow. Scaffolds or matrices (matrix) provide a specialized template or pathway, which is conductive for tissue growth (thus the term osteoconductive implies a scaffold for bone growth). Morphogens or growth factors, through a chemical or physical factor, stimulate cell activity and differentiation to produce bone, cartilage, meniscus, etc. Finally, genetic engineering, a slightly different twist, uses some vector (usually a virus), which transfects a cell with the intent to insert a segment of DNA such that the cell produces a protein or morphogen from the specific inserted genetic code. In summary, these mechanisms create new tissue and are described with the suffix "genesis."[1,2]

For tissue regeneration to occur successfully, at least 2 of the 3 mechanisms are required. Nonetheless, regenerate can occur with 1 of the 3 but is less reliable and requires a completely normal host bed as is seen in this study by Gastel et al. However, as recently noted at an AAOS symposium on tissue engineering, the most reliable technique of tissue regeneration was to have all 3 components present.[2] Of the 3, cells for regrowth are the key ingredient and have been the most difficult to create as a straightforward preparation, especially in cartilage, tendon, and meniscus.[2] The process of creating stem cells for connective tissue regeneration was pioneered with advances in skin replacements, and these techniques and concepts are being applied to the musculoskeletal system.[2] These applications have evolved at different rates and appear in the following order of current clinical applications: bone, hyaline cartilage, tendon/ligament, and as noted in the reviewed animal study, the meniscus.

In the study by Gastel et al, primarily the scaffold ingredient for the tissue engineering recipe for meniscal regeneration is used, as in another study performed by Stone et al.[3] Regeneration in such a strategy is dependent upon cell ingrowth and local growth factors. The SIS material is known to contain numerous growth factors as well and may offer an advantage in tissue regeneration. The SIS graft was resorbed, did not produce degenerative or synovial changes about the knee, and did appear to heal better than control. The potential availability and clinical application of this porcine-derived collagen scaffold is exciting. Interestingly, Arnoczky used a fibrin clot which also produced significant meniscal regeneration.[4] The fibrin clot contains both growth factors and a scaffold, and although cellular, not of the stem cell type. Reliable success with the collagen scaffold may likely involve addition of the 2 remaining ingredients, cells and growth factors, with the latter probably more readily available.

In summary, the orthopaedist must learn the concepts of tissue engineering to evaluate potential devices or implants based on the major 3 components: cells, scaffolds, and growth factors. Successful tissue regeneration of the meniscus is nearing a reality and studies such as this one make it 1 step closer. ❖

References

1. Schenck RC. Strategic strategies: Contemporary tissue engineering. *Medscape*. 2001.
2. Goldberg VM, et al. Tissue engineering: A contemporary treatment strategy for musculoskeletal tissue loss. Presented at: Annual Meeting of American Academy of Orthopaedic Surgeons, Symposium; March 2, 2001;San Francisco, Calif.
3. Stone KR, et al. Regeneration of meniscal cartilage with use of a collagen scaffold: Analysis of preliminary data. *J Bone Joint Surg*. 1997;79:1770-1777.
4. Arnoczky SP, et al. Meniscal repair using an exogenous fibrin clot: An experimental study in dogs. *J Bone Joint Surg*. 1988;70:1209-1217.

Nip and Tuck for MDI

ABSTRACT & COMMENTARY

Synopsis: *Laser shrinkage plus tightening of the rotator interval resulted in 96% success for shoulder multidirectional instability.*

Source: Lyons TR, et al. Laser-assisted capsulorrhaphy for multidirectional instability of the shoulder. *Arthroscopy*. 2001; 17(1):25-30.

Lyons and colleagues report on their experience with the use of the Holmium:Yag laser to assist with capsular shrinkage for multidirectional shoulder instability. Inclusion criteria were patients with at least 2 planes of instability and no evidence of Bankart tear or labral detachment. Interestingly, only 3 patients had generalized ligamentous laxity. It seems that the rest of these were a combination of traumatic and atraumatic capsular stretch type patients with primarily inferior instability. All patients had failed at least a 3-month nonoperative treatment program.

Twenty-six consecutive patients were followed over an average of 27 months and a minimum of 2 years. Follow-up was available for all patients. Twelve patients were competitive athletes and 6 sustained documented dislocations, while the remaining patients had subluxation episodes. Surgery included laser shrinkage of the entire capsule. In patients whom the rotator interval did not shrink with the laser, suture plication was performed. This was done on all but 3 patients.

Twenty-six of 27 shoulders remained stable and asymptomatic at a minimum of 2 years. A total of 86% of the 12 athletes returned to their previous level of sports. Only 1 patient suffered dislocations postoperatively who had Ehlers-Danlos syndrome.

■ COMMENT BY DAVID R. DIDUCH, MS, MD

This paper raises more questions than it answers. The results certainly are excellent. It is hard to argue with 96% clinical success with a consecutive series of patients and 100% follow-up. The real question is why did they do so well. Recent papers presented at the Academy are suggesting only about a 50% success rate with thermal shrinkage alone if done in the absence of some capsular shift or Bankart reattachment. Is the difference the laser compared to the radiofrequency probes? Instead, I would suggest that the difference is in the suture plication of the rotator interval. What we really need are controlled prospective studies that compare the laser to the radiofrequency probe, and shrinkage with or without plication of the rotator interval.

The rotator interval is an area that can be difficult to assess arthroscopically and difficult to treat. This article does provide helpful figures for passing a suture around the interval and tightening it arthroscopically. Patients who have a large sulcus sign that does not reduce with external rotation with the arm at the side should be suspected of having a rotator interval lesion. Given that the primary component of instability for these patients was inferior, it may be that the rotator interval plication was the difference. Interestingly, William Bennett, MD, offers another article in the same issue of *Arthroscopy* describing how to arthroscopically visualize the anatomy of the rotator interval and detect a tear.[1]

While these researchers are to be congratulated on their excellent results and sound methodology for this study, I believe we still need prospective studies with control groups to better understand what intervention or combinations thereof are necessary for success. Perhaps their database is sufficient to review all of those patients with and without rotator interval plication over a period of years to see if that is what made a difference. ❖

Reference

1. Bennett WF. Visualization of the anatomy of the rotator interval and bicipital sheath. *Arthroscopy*. 2001; 17(1):107-111.

ACL Tunnel Expansion Expanded

ABSTRACT & COMMENTARY

***Synopsis:** Tunnel expansion is not a problem peculiar to hamstring ACL reconstructions. Tibial tunnel expansion was seen by CT in patients reconstructed with patellar tendon grafts and followed over a 2-year period.*

Source: Fink C, et al. Tibial tunnel enlargement following anterior cruciate ligament reconstruction with patellar tendon autograft. *Arthroscopy.* 2001;17(2):138-143.

Although its clinical significance is unclear, tibial tunnel enlargement does occur, even with patella tendon autografts. In this paper, 34 patients had sequential CT scans and clinical evaluation following ACL reconstruction with patellar tendon autografts. The diameters of the tibial tunnel were noted to increase more than 30% in the sagittal plane and 16% in the coronal plane within 2 years. The enlargement was largest in the mid-portion of the tunnel, with expansion of almost 50% in the sagittal plane. Sequential studies demonstrated that tunnel enlargement began early in the postoperative period, reaching almost 50% of maximum enlargement within the first few weeks postoperatively. There was no correlation found between tunnel expansion and clinical results.

■ **COMMENT BY MARK D. MILLER, MD**

Tunnel enlargement following ACL reconstruction is a current focus of much investigation. Although most authorities agree that it is of no known clinical consequence, it certainly has implications for revision surgery. From what I have learned through my own experience, I always use back-up fixation for revision cases.

I discussed this topic in a previous review and concluded that, at least for the femoral side of hamstring ACL reconstructions, more tendon placed in the tunnel and improved fixation might reduce the amount of enlargement.[1] Others have suggested that aperture fixation (typically with a bioabsorbable screw) may reduce the incidence of tunnel enlargement. A recent study, however, demonstrated increased enlargement (122%) with this method of fixation vs. other devices.[2] In fact, this study reported that the EndoButton had the lowest amount of enlargement (36%) of all the devices studied. Clatworthy and associates concluded that tunnel widening cannot be avoided by fixing the graft closer to the joint or eliminating the bungee cord.

Returning to the present study, it is interesting that this phenomenon also occurs with patellar tendon grafts. According to the authors, it does not occur on the femoral side, presumably because the bone block is fixed immediately adjacent to the intra-articular margin, but perhaps also because of gravity effects. Fink et al also should be commended for using serial CT scans to accurately characterize this phenomenon. Undoubtedly there will be more papers to follow on this topic—stay tuned! ❖

References

1. Miller M. Tunnel expansion with EndoButton in hamstring ACLs. *Sports Medicine Reports*. 2001;3(1):2-3.
2. Clatworthy MG, et al. Tunnel widening in hamstring ACL reconstruction: A prospective clinical and radiographic evaluation of four different fixation techniques. In: Program and abstracts of the Annual Meeting of the American Academy of Orthopaedic Surgeons. February 28-March 4, 2001; San Francisco, Calif; Poster PE014 (Abstract) 369-370.

The Value of Strength Training in Children

ABSTRACT & COMMENTARY

***Synopsis:** Resistance training in children can result in significant strength gains without excessive risk of injury.*

Source: Guy JA, Micheli LJ. Strength training for children and adolescents. *J Am Acad Orthop Surg*. 2001;9:29-36.

As the intensity of sport participation for young athletes increased in the 1970s and early 1980s, many looked to strength training to enhance performance in this age group. Questions arose over the safety and effectiveness of such an activity in the prepubescent and pubescent child. The senior author of this review article, Micheli, has been active in research in this area for several decades and has been an integral part of many of the intense discussions on the subject.

In the present article, Guy and Micheli define a strength training program as a controlled, individualized activity involving a timely progression in intensity. It uses free weights, individual body weight, hydraulics, elastic bands, or similar equipment to increase one's ability to exert or resist force. Strength training, in this context, is used synonymously with resistance training but is distinct from power lifting or weight training where high-intensity training is used in an effort to be able to lift maximal weight.

Guy and Micheli critique the available literature on the effectiveness and risks of strength training in children, concluding, "current evidence indicates that resistance training can result in marked strength gains in the pubescent child without a significant risk of injury. However, the duration and intensity of training needed for maximal results has not been clearly defined. Moreover, such strength gains from resistant training appear to be transient with the degree of training regression dependent on the magnitude of strength gains, level of inactivity, and duration of detraining. Surprisingly, there does not appear to be any sex- or age-related differences to training in this age group."

Although the effect of factors such as muscle hypertrophy, increase in muscle cross-sectional area, motor-unit coordination, central nervous system activation, and psychological drive on strength increases in adults have been studied extensively, Guy and Micheli remind us that little is known regarding how and why strength gains occur in children following proper resistant training regimes.

■ COMMENT BY LETHA Y. GRIFFIN, MD, PhD

Children today are under increased pressure to excel in sports. Our society equates success with wining, not merely doing your best. Moreover, athletic excellence brings with it tremendous social and financial rewards. In women's sports such as dance, skating, and gymnastics, the peak of one's athletic career is frequently the mid-teenage years. Hence, there is a need to know how, at a very early age, one can best maximize strength and performance without causing injury.

In 1985, members of the National Strength and Conditioning Association met with physicians and educators to review available literature on relative risks and benefits of strength training for the prepubescent athlete and to establish a policy statement on the same. They concluded that resistance training in youth helped to increase fitness and minimize sport injury. Now, almost 20 years later, Guy and Micheli, after reviewing the current literature, arrive at a similar conclusion—that is, that prepubescent and pubescent children, participating in well-designed strength training programs, can increase muscle strength with little risk of injury provided they do so in a well-designed, progressive-resistance training program. Moreover, such strength gains appear to be "the result of increased neuromuscular activation and coordination" rather than a consequence of muscle hypertrophy. This article is an excellent review for those involved in the supervision or medical care of youth sport participants. ❖

CME Questions

26. Resistance training in children:

a. is an excellent way to increase strength.
b. is synonymous with weight training in this age group.
c. unfortunately, is associated with a high risk of injury in the pubescent child.
d. results in significant muscle hypertrophy.

27. One can increase the safety of pole vaulting by:

a. increasing the amount of padding at the landing pit.
b. placing sand around the landing pit.
c. improving coaching techniques.
d. All the above

28. Meniscal regeneration based on tissue engineering techniques has most commonly involved which one of the following components?

a. Collagen scaffolds
b. Stem cells
c. Growth factors
d. Artificial substitutes

29. Endurance running athletes have:

a. a similar chance of developing knee disability as prior team sports athletes.
b. an increased chance of developing hip disability compared to the general population.
c. a similar chance of developing knee disability as the general population.
d. an increased chance of developing knee disability compared to the general population.

30. Which of the following correctly describes the effects of therapeutic magnets in comparison to a sham treatment?

a. Blood flow is increased.
b. Surface temperature of skin is increased.
c. Intramuscular temperature is increased.
d. None of the above

31. In addition to laser-assisted capsular shrinkage, what other surgical procedure was used to achieve success for patients with multidirectional instability?

a. Insertion of absorbable tacks
b. Arthroscopic capsular shift
c. Arthroscopic Bankart repair
d. Suture plication of the rotator interval

32. ACL tunnel enlargement:

a. only occurs following hamstring ACL reconstruction.
b. occurs on both the femoral and tibial sides of both hamstring and patellar tendon reconstructions.
c. occurs on both sides of hamstring reconstructions, but only on the tibial side of patellar tendon reconstructions.
d. occurs on both sides of hamstring reconstructions, but only on the femoral side of patellar tendon reconstructions.
e. only occurs following patellar tendon ACL reconstruction.

Readers are Invited. . .

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In Future Issues:

Tissue-Engineered Rotator Cuff Tendons