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The Effect of Face Shields on Head and Neck Injuries in Ice Hockey

ABSTRACT & COMMENTARY

Synopsis: *Full-length face shields significantly reduced the risk of facial and dental injuries without an increase in concussions or neck injuries.*

Source: Benson BW, et al. Head and neck injuries among ice hockey players wearing full face shields vs half face shields. *JAMA* 1999;282(24): 2328-2332.

Ice hockey is known to be a fast and violent sport with frequent collisions between players and equipment resulting in injury. Many hockey associations across the United States and Canada have recently introduced rules requiring the use of face masks to help reduce facial injuries. At the same time, some have noted a trend of increased cervical spine injuries, leading to speculation that a full face shield may alter the spine biomechanics to increase injury risk. Another possibility is that style of play may be more aggressive with the full shield. This paper by Benson and colleagues from the University of Calgary in Alberta sought to determine whether full face shields alter the risk of head and neck injuries as compared to half face shields.

During the 1997-1998 season, 22 teams (642 players) were equally divided by use of full vs. half face shields based on rules unique to different Canadian intercollegiate divisions. After a preseason baseline examination players were prospectively followed during all practices and games, with all injuries recorded by the team trainer and/or physician. Reportable injuries were those involving facial, head, neck, or brachial plexus stretch (stinger-type) injuries or any injury resulting in at least one missed practice or game. A power analysis using injury data from the prior season was used to calculate sample size.

Practice and game participation information was 100% complete and injury information was obtained for 99.9% of cases involving missed time due to injury. Approximately 25,000 athlete exposures

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were accumulated for each group during the season. Although nearly equal numbers of athletes sustained injuries in each group (61% full shield and 63% half shield), there was a statistically significant difference in the types of injuries sustained. The number of players in the half shield group sustaining head and face injuries was nearly triple that in the full shield group (relative risk, 2.52). The risk of sustaining a dental fracture was 9.9 times greater and a facial laceration was 2.3 times greater for the half shield group. There was no difference in the rate of concussions between the two groups; however, the half shield group missed about twice as much time from practices and games due to concussions. Neck injuries were similar between groups, with five in the full shield group and seven in the half shield group.

COMMENT BY DAVID R. DIDUCH, MS, MD

This study by Benson et al seeks to dispel the myth that full face shields increase the risk of head and neck injuries. Using a prospective cohort design, Benson et al effectively demonstrated that there was no difference in the incidence of concussions or neck injuries between players wearing full or half face shields. The two groups were similar in every way except for face shield length, and data collection was nearly 100% complete using a validated system for injury surveillance. Sample size was also adequate and determined by a power analysis based on prior injury rates.

Thus, we can conclude that this study was well designed to determine the effect of face shield length on injuries in ice hockey. Differences in injury rates were striking, with two and a half times the number of head injuries and facial lacerations, and nearly 10 times the number of dental injuries (despite wearing mouth guards). Interestingly, time lost from participation due to concussion was greater for the half shield group, suggesting more severe injuries. Because players frequently are seen wearing the helmets more loosely and tipped back on the head to improve vision under the half shield, this may reduce the protective effect of the helmet.

This paper makes a strong argument for use of full face shields in ice hockey. The protective effect was significant, and no increased risk of injury was identified. One issue not addressed was player visibility and whether skills were compromised. If that is not a problem, it would be difficult for anyone to object to the use of full face shields. ❖

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ACL Injury Incidence Among Male and Female Professional Alpine Skiers

ABSTRACT & COMMENTARY

Synopsis: *ACL injury rates are similar in male and female professional alpine skiers.*

Source: Viola RW, et al. Anterior cruciate ligament injury incidence among male and female professional alpine skiers. *Am J Sports Med* 1999;27(6):792-795.

In an effort to further outline gender-based anterior cruciate ligament (ACL) injury rates, Viola and colleagues from the Steadman Hawkins Sports Medicine Clinic retrospectively reviewed knee injury rates in professional alpine skiers. Using a database composed of 7155 ski patrollers or instructors (4537 men, 2618 women), Viola et al followed injury rates based on documentation through workmen's compensation reporting between 1991 and 1997 at one ski resort. The men skied an average of 110 days per year, with women skiing an average of 89 days per year. The incidence of ACL disruption was 4.2 injuries per 100,000 skier-days in men and 4.4 injuries per 100,000 skier-days in women. A total of 31 ACL injuries were noted, 21 in men and 10 in

women. Interestingly, demographics were statistically different for age of the participants, with women averaging 26 years and men averaging 33 years (P = 0.013). Although the number of skier-days between men and women also was significantly different, injury rates were normalized per skier-days to correct for this.

Viola et al hypothesized the similarity in injury rates is related to the mechanism of injury in skiing being valgus with internal rotation, or a direct anterior force generated by the ski boot. Whereas there are well-documented differences in injury rates between NCAA men and women collegiate basketball and soccer players, their mechanism of injury is usually sudden deceleration, twisting, or hyperextension. Although the age differences are significant, Viola et al reference a previous study by Greenwald et al that noted no age-related differences in injury incidence in skiers.[1] In that study, however, gender-specific injury rates were different in skiers. Nonetheless, Viola et al report the first gender-specific ACL injury incidence study in a controlled population of alpine skiers revealing relatively similar injury incidence of ACL tears in men and women.

COMMENT BY ROBERT C. SCHENCK, Jr., MD

This article is another excellent addition to the knowledge base of gender-specific ACL injury rates. Using the "journeyman" professional skier (ski instructor or patroller) is a unique way to have a captured population where injuries will be accurately reported and documented. Thus, the days of exposure, numbers of participants, and injuries reported will be accurate. In this population, the male skier is older than the female skier but injury rates are equal. Viola et al noted the physical conditioning and skill level of both the men and women was excellent based on preseason evaluations.

The similar injury rates are probably best explained by the level of skiing performed. As Viola et al noted, "Most professional skiers spend a significant amount of their time skiing below their ability level." It would be interesting to evaluate NCAA injury rates between males and females in alpine skiing as performed by Arendt and Dick in soccer and basketball.[2] Possibly, during competition, and skiing daily at one's skill level, injury rates between men and women may differ as seen in previous studies. Further study is needed in this interesting area of sports injury. ❖

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The Role of the Biceps Tendon

ABSTRACT & COMMENTARY

Synopsis: *The biceps tendon (BT) may add some glenohumeral joint stability, but the magnitude of force transmitted through active BT contraction is small and possibly insignificant.*

Source: Goldfarb C, Yamaguchi K. The biceps tendon: Dogma and controversies. *Sports Med and Arthroscopy Rev* 1999;7: 93-102.

The role of the long head of the biceps tendon (BT) in shoulder motion and stability has been debated for many years. The BT was originally thought to be a primary source of shoulder pain. EMG data from the 1950s showed the BT to play an active role during shoulder forward flexion and abduction,[1] therefore correlating biceps activity with shoulder mobility and stability. In 1972, Neer described the pathology of rotator cuff impingement and identified anterolateral acromial spurring as a primary source of shoulder pain. He showed that acromioplasty alone could relieve pain even in shoulders with significant BT degeneration. Neer warned against unnecessary biceps tenodesis because he felt that the biceps tendon imparted active humeral head depression.[2]

In this review of the literature, Goldfarb and Yamaguchi cite several basic scientific, anatomic, and biomechanical studies to elucidate the true role of the BT. An anatomical comparative study showed that the BT progresses anteromedially as quadripeds are compared to bipeds. This loss of abduction force has been compensated by developmental adaptation of the deltoid muscle.[3,4] Hitchcock and Bechtol thus concluded that tenodesis of the BT does not "materially weaken the shoulder."[3] Several EMG studies have documented biceps muscle activity during shoulder motion, but most of the activity was actually related to elbow flexion.[4-6] Two recent studies showed no significant biceps muscle activity related to shoulder activity when elbow activity was eliminated by bracing the elbow.[7] One in vivo study measured a small increase in superior humeral head translation during shoulder

abduction in seven patients with loss of BT activity. Goldfarb and Yamaguchi thus conclude that the BT may add some glenohumeral joint stability, but the magnitude of force transmitted through active BT contraction is small and possibly insignificant.

COMMENT BY STEPHEN B. GUNTHER, MD

Controversy about the role of the long head of the BT has existed for many years. It is widely accepted that the BT plays a role in the rotator cuff impingement syndrome. An inflamed or partially torn BT can cause anterior shoulder pain. However, the role of the BT in glenohumeral joint stability is not universally agreed upon. Therefore, opinions differ about the use of tenodesis of the BT as a solution for painful, degenerative afflictions of the tendon.

Does tenodesis of a diseased biceps tendon alter function of the shoulder? It would appear from this review that the biceps provides a minimal contribution to shoulder stability, although the contribution may be more significant in cases of rotator cuff dysfunction. In light of the fact that patients who spontaneously rupture the BT long head often do well, some surgeons now recommend tenotomy rather than tenodesis for a damaged tendon. This is an area that needs further study.

This article is a must read for any practitioner who is intrigued by the long head of the biceps tendon. There is a thorough discussion about the role of the BT in the human shoulder as well as the pathophysiology and treatment options. ❖

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Failure of PCL Reconstructions . . . The Unrepaired PLC

ABSTRACT & COMMENTARY

Synopsis: *This biomechanical study demonstrates that a posterior cruciate ligament (PCL) reconstruction can restore normal knee kinematics. However, an unrepaired posterolateral corner (PLC) significantly increases translational motion in the knee as well as the forces in the reconstructed PCL ligament.*

Source: Harner CD, et al. Biomechanical analysis of a posterior cruciate ligament reconstruction. Deficiency of the posterolateral structures as a cause of graft failure. *Am J Sports Med* 2000;28(1):32-39.

This is a biomechanical analysis of the human knee comparing the translation, forces, and moments in knees that were intact, PCL deficient, PCL reconstructed, and PCL reconstructed with surgical resection of the PLC. Test conditions included a posterior force, external torque, and varus moments at 30° and 90° of knee flexion. A previously described robot was used to test the translation, forces, and moments. An 11-mm Achilles graft was used for the anatomic PCL reconstructions. The testing procedure followed the order of: intact knee, PCL deficient, PCL reconstructed, and, lastly, PCL reconstructed and PLC deficient.

The results demonstrated that, using this surgical technique and under these testing conditions, the PCL-reconstructed knee kinematics were within 3 mm of the intact knee. However, sectioning of the PLC increased external rotation, varus, and posterior tibial translation. Furthermore, sectioning of the PLC caused an increase in the forces transmitted to the reconstructed PCL graft.

COMMENT BY JAMES R. SLAUTERBECK, MD

PCL reconstruction historically does not yield the same good results as anterior cruciate reconstructions. Many factors may lead to this, including improper diagnosis, poor surgical technique, poor graft choice, and improper rehabilitation emphasizing early hamstring activity and the supine position. Appropriate rehabilitation for the PCL-reconstructed knee was reported in the March *Sports Medicine Reports* review of the Hoher et al article addressing the importance of the quadriceps in the early rehab phases.[1]

This well-designed study addresses biomechanically how untreated PLC injuries could adversely affect surgical

results of PCL reconstructions by increasing anteroposterior (AP) and rotational translation and placing higher than desired forces on the PCL-reconstructed graft. In addition, this study demonstrates that immediately after a PCL reconstruction, relatively normal knee kinematics can be obtained in a cadaver model. This is important to document because many studies demonstrate increasing knee laxity postoperatively and others have questioned the ability to properly restore the knee kinematics with surgery.

This study highlights the need for the physician to thoroughly diagnose all clinical laxity in the knee. Posterior and rotational testing of the knee at both 30° and 90° is important. Demonstration of increased external rotational laxity and posterior tibial translation at 30° and 90° should lead one to make the diagnosis of a combined ligament injury involving the PCL and PLC. Isolated PLC injuries will demonstrate excessive external rotation at 30° with decreasing external rotation at 90°. Isolated PCL injuries will demonstrate increased AP laxity at 30° and 90° without concomitant increases in rotation. Increases in hyperextension and rotation at 30° and 90° should lead one to search for combined ligament injury involving the PCL and the posterolateral structures.

This paper provides sound biomechanical evidence to support my opinion that anatomic reconstructions for the PCL can be successful if care is taken to reconstruct the ligament and all associated posterior lateral corner injuries. An appropriate rehabilitation program must be strictly followed. ❖

Reference

1. Slauterbeck JR. How muscle forces affect loads on the PCL. *Sports Med Rep* 2000;2(3):21-22.

Pectoralis Major Tendon Repair

ABSTRACT & COMMENTARY

Synopsis: *Pectoralis major tendon repair for both acute and chronic injuries shows significantly better outcomes than nonoperative treatment.*

Source: Schepsis AA, et al. Rupture of the pectoralis major muscle. Outcome after repair of acute and chronic injuries. *Am J Sports Med* 2000;28:9-15.

Schepsis and colleagues retrospectively reviewed 17 cases of pectoralis major muscle rupture in order to compare nonoperative vs. operative treatment of acute and chronic injuries. They define an acute injury as less than two weeks from injury to surgical repair. There were six acute repairs, seven chronic repairs, and four patients with no repair. Subjective and objective outcome questionnaires showed patient satisfaction to be 96%, 93%, and 51%, respectively. Isokinetic adduction strength testing was performed, which also showed improved results with surgical repair (102%, 94%, and 71%, respectively). Patient satisfaction with cosmetic results was recorded as an average of 84% in both operative groups and 56% in the nonoperative group. All of the surgeries were performed by Schepsis using an identical technique of suture repair through a bony trough in the humerus tied over a bone tunnel. Schepsis et al conclude that, although their sample numbers were small, all patients treated surgically fared significantly better subjectively and objectively than those treated nonoperatively. "Furthermore, delayed repair does not significantly compromise the subjective or objective results of surgery," according to Schepsis et al.

COMMENT BY STEPHEN B. GUNTHER, MD

This retrospective review of pectoralis major tendon rupture does shed some light on this rare type of injury. There are many reports in the literature with small numbers of subjects, but it is difficult to collect a large series of patients by any one surgeon with such a rare injury. This case series, however, reports a significant improvement in patient satisfaction and adduction strength. It is also interesting to note that there was no significant difference in results between the acute and chronic repair groups. It also would be interesting to evaluate patients with a treatment delay of more than 12 months.

Schepsis et al also elucidate an increasing trend in pectoralis major tendon ruptures due to weightlifting activities. The majority of these injuries (8/10) occurred during use of the bench press. The biomechanics of the bench press exercise have been well studied by Elliott et al, but the prevalence of pectoralis tendon ruptures in weightlifters has not been specifically studied.[1] A review of the literature demonstrates that most pectoralis major tendon ruptures occur in males involved in heavy lifting activities in either the work environment or sports.[2,3]

In summary, this paper sheds light on a rare injury. Patient outcomes were improved by surgical reconstruction of the pectoralis major musculotendinous unit for both acute and relatively chronic tears. It would be beneficial to perform a collaborative collation of data from multiple surgeons in order to increase the number of patients with chronic tendon repairs with more than a one-year delay in surgery. ❖

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The Effect of Radiofrequency on Articular Cartilage

ABSTRACT & COMMENTARY

Synopsis: *Although the new radiofrequency probes do not cause penetrating injury at time zero, the long-term effects on chondrocytes are not known.*

Source: Kaplan L, Uribe JW. The acute effects of radiofrequency energy in articular cartilage: An in vitro study. *Arthroscopy* 2000;16(1):2-5.

Radiofrequency (rf) probes have become popular arthroscopic tools for soft tissue ablation and shrinkage. The indications for RF have been expanded to include chondroplasty or debridement of partial thickness articular cartilage lesions; however, the effects of RF on chondrocytes and the surrounding matrix have not been well studied.

Kaplan and Uribe examined the acute effects of RF on human articular cartilage harvested during total knee replacements. Six knees with unicompartmental osteoarthritis were used to harvest specimens from both intact and fibrillated areas. Cartilage specimens were placed in a simulated, arthroscopic, saline environment and treated with the Arthrocare bipolar RF probe. Low, medium, and high voltage settings each were delivered to the surface by lightly brushing the surface with the probe for three seconds. Specimens were then immediately fixed, decalcified, sectioned, and prepared with a variety of stains.

Kaplan and Uribe could not determine a difference between the three voltage settings histopathologically, so they considered the specimens together. The RF probe effectively removed the articular cartilage, leaving a smooth, scalloped surface, even for the fibrillated cartilage. Higher settings removed proportionately more cartilage. A thin, tan film on the surface represented coagulated tissue fragments. Both the matrix and the chondrocytes immediately adjacent to the treated borders appeared undisturbed. Because the chondrocytes appeared unchanged on histology, they were presumed to be viable. The fibrillar collagen pattern also appeared unaltered by polarized light microscopy. The only difference noted by Kaplan and Uribe was a decreased uptake of proteoglycan-specific stains such as Alcian blue adjacent to the treatment area.

COMMENT BY DAVID R. DIDUCH, MS, MD

Bipolar RF probes deliver thermal energy in a localized fashion at a relatively low temperature (100°-160°C) when compared to standard unipolar electrocautery (400°-600°C). As such, the depth of penetration, and presumed injury to adjacent tissue, is reduced. This has been an advantage over laser treatment that has been associated with an energy-dependent zone of necrosis with associated complications.[1] Likewise, bipolar RF was shown to be superior to mechanical debridement with a rotary shaver in a sheep model by demonstrating less destruction of adjacent normal cartilage.[2]

While on the surface it would appear that these new bipolar RF probes were superior to other methods of cartilage debridement, a closer look at these studies warrants a word of caution. Kaplan and Uribe, as they acknowledged, examined the effects of RF at time zero on cartilage. No data are presented concerning how the thermal energy affects the surrounding chondrocytes and matrix over time. Histological inspection does not confirm viability of the chondrocytes. It is quite possible that the thermal energy may injure the chondrocytes, leading to a delayed death and subsequent loss of matrix. These chondrocytes initially would appear quite normal. Our own experience, with a limited number of second-look arthroscopies, suggests that this may occur as we have noted progressive deepening of the treated area with time.

Kaplan and Uribe admit this shortcoming in their paper and state that they are examining this issue with other studies. To their credit, the paper is well constructed and, with the exception of the statement concerning chondrocyte viability, their conclusions well supported. They provide an excellent addition to the scant literature on the subject and address an issue not covered in the sheep study by Turner. That is, how do the effects on fibrillated cartilage differ compared to intact cartilage. Because the surface area is increased with fibrillations, it is possible that the thermal effects on the cells are more pronounced. Kaplan and Uribe demonstrate that, at least at time zero, there does not appear to be much difference in the remaining tissue surrounding the ablation area.

The visual assessment of the RF probe's ability to contour the cartilage surface during chondroplasty is impressive. It would seem that these will be helpful additions to our arthroscopic tools. However, we should be cautious until we know the long-term effects of RF energy on the chondrocytes and whether the treated area changes over time. Likewise, these studies do not translate into clinical outcomes. That is another major gap in the literature on this subject. ❖

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Instrumented Measurement of Ankle Laxity

ABSTRACT & COMMENTARY

Synopsis: *Clinically objective and reliable measures of ankle displacement and rotation were demonstrated with the use of a portable ankle arthrometer in subjects without a history of injury to the ankle.*

Source: Kovaleski JE, et al. Instrumented measurement of anteroposterior and inversion-eversion laxity of the normal ankle joint complex. *Foot Ankle Int* 1999;20(12):808-814.

Kovaleski and colleagues used a portable ankle arthrometer to measure dominant and nondominant ankle anteroposterior (AP) translation and inversion-eversion (I-E) rotation, and determined the test-retest reliability and precision of the device. The arthrometer consisted of an adjustable plate fixed to the foot, a load-measuring handle attached to the foot plate, and a pad attached to the tibia. Subjects were tested while supine on a table with the knee in extension and the heel securely fixed on the foot plate. A computer with an analog-to-digital converter recorded six-degrees-of-freedom motion. AP displacement in millimeters was measured at 75 N, 100 N, and 125 N force loads. I-E rotation in degrees was recorded at 2000 N-mm, 3000 N-mm, and 4000 N-mm loads. The measurements reflected the motion of the calcaneus with respect to the tibia. The ankles of 41 male and female volunteers without a history of previous injury were tested at 0° of flexion.

To determine intratester reliability for both AP and I-E measurements, the device was removed and then repositioned for a retest procedure, and intraclass correlation coefficients were calculated. The standard error of measurement was used to estimate precision of measurement, and t-tests were used to compare differences between dominant and nondominant sides. An ICC of 0.75 or better was considered high reliability of measurement.

The reliability coefficients ranged from 0.82 to 0.89 for AP displacement, and 0.86 to 0.97 for I-E rotation. The range of AP displacement was from 10.18 mm (SEM = 1.23) at 75 N load to 18.47 mm (SEM = 2.06) at the 125 N load. For I-E rotation, the range was from 23.14° (SEM = 1.74) at 2000 N-mm to 47.41° (SEM = 2.47) at 4000 N-mm. No significant differences were found between dominant and nondominant sides for AP displacement and I-E rotation.

COMMENT BY DAVID H. PERRIN, PhD, ATC

Instrumented measurement of knee joint displacement has received a great deal of attention in the scientific literature and in orthopedic practice. The advantages of instrumented arthrometry over clinical measurements are standardization of applied force and quantification of observed displacement. This study demonstrated high reliability and precision of measurement using a portable ankle arthrometer. As with the KT1000 knee arthrometer, the advantage of a portable ankle arthrometer is the ability to measure displacement without the need for stress radiography.

As with any laboratory or clinical instrument, it is important to establish the reliability and precision of joint arthrometers. While the study of healthy populations is a logical starting point, the primary limitation of this paper was that subjects with a history of ankle ligamentous injury were not included in the study. The reliability of ankle arthrometry in healthy subjects cannot be generalized to patients who have partial or complete ligament tears. As such, the next phase of establishing the reliability and validity of this device should include assessment of the injured population for which the device has been designed.

Additional limitations of the device would appear to be related to test position and isolation of the joints contributing to motion of the ankle. The sensitivity of the device in assessing the structures most commonly injured with inversion ankle sprain might be enhanced if measurement of I-E rotation occurred with foot placement in plantar flexion, rather than the position of 0° of flexion described in the methods of this study. Others have discussed the importance of determining the indi-

vidual contribution of talocrural and subtalar joint laxity to ankle joint instability, in order to effectively treat patients with recurrent ankle sprain.[1] The arthrometer used in this study measures the sum of motions at the talocrural and talocalcaneal joints, and thus does not quantify the individual contribution of these joints to instability of the ankle complex. Separating the contribution of each component of instability diagnostically would help direct therapeutic intervention.

Joint arthrometers are not without their limitations, yet they do provide some advantages for the quantification of laxity and the accompanying functional instability that frequently occurs with joint injury. Kovaleski et al have made a useful contribution to our understanding of instrumented assessment of laxity of the normal ankle joint complex. ❖

Reference

1. Hertel J, et al. Talocrural and subtalar joint instability after lateral ankle sprain. *Med Sci Sports Exerc* 1999;31(11):1501-1508.

CME Questions

23. Full face shields, as compared to half shields, were found in ice hockey to:
a. reduce dental injuries by nearly 10-fold.
b. reduce facial lacerations by 2.3-fold.
c. reduce head and facial injuries by 2.5-fold.
d. not affect the rate of neck injuries.
e. All of the above

24. The rate of ACL tears in female skiers compared to male skiers was:
a. half less.
b. twice more.
c. equal.
d. sevenfold.

25. Which statement is incorrect regarding the long head of the biceps tendon?
a. It is often degenerated in patients with rotator cuff tears.
b. It is the primary active stabilizer of the glenohumeral joint.
c. It performs a different function in human beings than in quadripeds.
d. It may cause anterior shoulder pain when inflamed or partially torn.

26. A probable cause for failure of PCL reconstructive surgery is the:
a. use of a nonirradiated Achilles allograft.
b. use of a patellar tendon 11-mm allograft.
c. use of a patellar tendon 11-mm autograft.
d. failure to recognize concomitant PLC injury to the knee.

27. Patients with a pectoralis major tendon repair may expect to improve all of the following *except*:
a. adduction weakness.
b. cosmetic defect.
c. external rotation lag.
d. subjective outcome.
e. function even with a late repair of a chronic rupture.

28. The use of bipolar radiofrequency probes on articular cartilage has been shown to:
a. demonstrate minimal damage to surrounding cartilage at the time of treatment only.
b. be superior to mechanical debridement (shaving) in long-term clinical studies.
c. create a deep, thermal injury resulting in avascular necrosis.
d. not injure the surrounding chondrocytes, as demonstrated by long-term viability.

29. The ankle arthrometer used in the study by Kovaleski et al determined laxity by measuring:
a. talar tilt.
b. sum of motions at the talocrural and talocalcaneal joints.
c. talocrural motion.
d. subtalar motion.

In Future Issues:

Internal Impingement of the Rotator Cuff in Throwers
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Posterior Shoulder Instability