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Ten Worth Your Time:

**Recent Contributions to the Orthopaedic Literature from Our
Department**

1. Torg JS, Naranja RJ, Jr, Palov H, Galinat BJ, Warren R, and Stine RA: The relationship of developmental narrowing of the cervical spinal canal to reversible and irreversible injury of the cervical spinal cord in football players. *J Bone Joint Surg* 78-A:1308--1314, 1996.

Abstract: An evaluation of forty-five athletes who had had an episode of transient neurapraxia of the cervical spinal cord revealed a consistent finding of developmental narrowing of the cervical spinal canal. The purpose of the present epidemiological study was to determine the relationship, if any, between a developmentally narrowed cervical canal and reversible and irreversible injury of the cervical cord with use of various cohorts of football players as well as a large control group. Cohort I comprised college football players who were asymptomatic and had no known history of transient neurapraxia of the cervical cord. Cohort II consisted of professional football players who also were asymptomatic and had no known history of transient neurapraxia of the cervical cord. Cohort III was a group of high-school, college, and professional football players who had had at least one episode of transient neurapraxia of the cervical cord. Cohort IV comprised individuals who were permanently quadriplegic as a result of an injury while playing high-school or college football. Cohort V consisted of a control group of male subjects who were non-athletes and had no history of a major injury of the cervical spine, an episode of transient neurapraxia, or neurological symptoms. The mean and standard deviation of the diameter of the spinal canal, the diameter of the vertebral body, and the ratio of the diameter of the spinal canal to that of the vertebral body were determined for the third through sixth cervical levels on the radiographs for each cohort. In addition, the sensitivity, specificity, and positive predictive value of a ratio of the diameter of the spinal canal to that of the vertebral body of <0.80 was evaluated. The findings of the present study demonstrated that a ratio of <0.80 had a high sensitivity (93%) for transient neurapraxia. The findings also support the concept that symptoms may result from a transient reversible deformation of the spinal cord in a developmentally narrowed osseous canal. The low positive predictive value of the ratio (0.2%) however, precludes its use as a screening mechanism for determining the suitability of an athlete for participation in contact sports. Developmental narrowing of the cervical canal in a stable spine does not appear to

predispose an individual to permanent catastrophic neurological injury and therefore should not preclude an athlete from participation in contact sports.

2. Shafritz AB, Shore EM, Gannon FH, Zasloff MA, Taub R, Muenke M, and Kaplan FS: Overexpression of an osteogenic morphogen in fibrodysplasia ossificans progressiva. *N Engl J Med* 335:555--561, 1996.

Abstract: Fibrodysplasia ossificans progressiva is a heritable disorder of connective tissue characterized by congenital malformation of the great toes and postnatal formation of ectopic bone. Although the disorder was first described more than 300 years ago, the genetic defect and pathophysiology remain unknown. Bone morphogenetic proteins are potent bone-inducing morphogens that participate in the developmental organization of the skeleton, and increased production of one or more of these proteins has been proposed as the cause of fibrodysplasia ossificans progressiva. We studied lymphoblastoid cell lines established from peripheral-blood mononuclear cells of patients with fibrodysplasia ossificans progressiva and fibroblast-like cell lines derived from lesional and nonlesional tissue. We used Northern blot analysis and ribonuclease protection assays to measure the expression of messenger RNA (mRNA) on bone morphogenetic proteins 1 to 7 and immunohistochemical analysis to examine protein expression. Among the bone morphogenetic proteins and mRNAs examined, only bone morphogenetic protein 4 and its mRNA were present in increased levels in cells derived from an early fibroproliferative lesion in a patient with fibrodysplasia ossificans progressiva. Bone morphogenetic protein 4 mRNA was expressed in lymphoblastoid cell lines from 26 of 32 patients with fibrodysplasia ossificans progressiva but from only 1 of 12 normal subjects ($p < 0.001$). Bone morphogenetic protein 4 and its mRNA were detected in the lymphoblastoid cell lines from a man with fibrodysplasia ossificans progressiva and his three affected children (two girls and a boy), but not from the children's unaffected mother. No other bone morphogenetic proteins were detected. Overexpression of a potent bone-inducing morphogen (bone morphogenetic protein 4) in lymphocytes is associated with the disabling ectopic osteogenesis of fibrodysplasia ossificans progressiva.

3. Lotke PA, Palevsky H, Keenan AM, Meranze S, Steinberg ME, Ecker ML, and Kelley MA: Aspirin and warfarin for thromboembolic disease after total joint arthroplasty. *Clin Orthop* 324:251--258, 1996.

Abstract: This study compares the benefits of aspirin and warfarin prophylactic agents for patients with thromboembolic disease after total joint arthroplasty. It is a prospective randomized study of 388 patients having total hip or total knee surgery. All consecutive patients having total hip or total knee surgery were entered into this study and evaluated with preoperative and postoperative ventilation perfusion scans and a postoperative venogram. The aspirin and warfarin treatment groups were compared by size and location of venographically revealed clots and changes in ventilation perfusion scans. The results showed that there was no difference in the size or location of deep venous thrombosis in the aspirin or warfarin treatment groups. The venogram was negative in 44.5% of

patients; 28.8% had small calf clots, 16% had large calf clots, 3.9% had popliteal clots, and 6.7% had femoral clots. Patients with total knee replacement had 2.6 times greater incidence of calf deep venous thrombosis than patients with total hip replacement. There was no difference between the aspirin and warfarin groups in the incidence of changes in ventilation perfusion scans (18.9%). There was no difference between the two groups in bleeding complications. The results suggest that aspirin and warfarin are equivalent in prophylaxis against thromboembolic disease, as determined by prevention of venographic changes or changes in ventilation perfusion scans.

4. Copley LA, Dormans JP, and Davidson RS: Vascular injuries and their sequelae in pediatric supracondylar humeral fractures: toward a goal of prevention. *J Pediatr Orthop* 16:99--103, 1996.

Abstract: Between 1988 and 1994, 128 consecutive children with grade III supracondylar humeral fractures presented for treatment at our hospital. Seventeen had absent or diminished (detected with Doppler but not palpable) radial pulses on initial examination. Fourteen of these 17 children recovered pulse (palpable) after reduction and stabilization of their fractures. The remaining three had persistent absence of radial pulse. Each of these three children was explored immediately and found to have a significant vascular injury requiring repair. Two of the 14 children who had initially regained their pulses had a progressive postoperative deterioration in their circulatory status during the first 24--36 hours including loss of the radial pulse. Both of these children had arteriograms that identified vascular injuries. Both underwent exploration and bypass grafting. One of these two children had been transferred 48 hours after injury, resulting in delay of management of his vascular impairment. Despite exploration, vascular repair, and fasciotomy, he ultimately developed Volkmann's ischemic contracture. All five children with significant vascular injuries had absent or diminished radial pulses on presentation. Immediate reduction and fixation followed by careful evaluation and treatment of ischemia were associated with excellent outcome in four of the five children.

5. Torg JS, Thibault L, Sennett B, and Pavlov H: The Nicolas Andry Award. The pathomechanics and pathophysiology of cervical spinal cord injury. *Clin Orthop* 321:259--269, 1995.

Abstract: Cervical cord injuries caused during American football games have resulted in reversible, incompletely reversible, and irreversible neurologic deficits. An explanation for this variable response to injury has been obtained from the study of the histochemical responses of a squid axon injury model to mechanical deformation. Data obtained indicate that recovery or lack thereof is directly proportional to the intracellular calcium concentration which in turn is directly proportional to the amount and rate of tension applied to the axon. It is concluded that in most instances of acute spinal injury, disruption of cord function is a result of the effects of local cord anoxia and the increased concentration of intracellular calcium. It is proposed that implementation of therapeutic measures that restore blood flow and reduce cytosolic calcium will increase neurologic recovery.

6. Dormans JP, Drummond DS, Sutton LN, Ecker ML, and Kopacz KJ: Occipitocervical arthrodesis in children. A new technique and analysis of results. *J Bone Joint Surg* 77-A:1234--1240, 1995.

Abstract: A new wiring technique for occipitocervical arthrodesis was used in 16 consecutive children between 1985 and 1992. The 12 boys and four girls had an average age of nine years and six months (range 2 years, 5 months to 19 years, 3 months) at the operation. The arthrodesis was performed between the occiput and the second cervical vertebra in ten patients and between the occiput and the third cervical vertebra in six. The instability was related to congenital anomalies (six patients), decompression for cervical stenosis (four patients), Down syndrome (three patients), trauma (one patient), resection of a tumor (one patient), and neurofibromatosis (one patient). Six patients needed a laminectomy for decompression because of cervical stenosis or for removal of a tumor. All of the patients were managed with an autogenous bone graft from the iliac crest and postoperative immobilization with a halo device. Fusion was achieved in 15 of the 16 patients. Complications developed in seven patients. The use of wire fixation, combined with the inherent stability of the bone-graft construct, allowed for removal of the halo device relatively early (range, 6--12 weeks), before the fusion was fully mature. No graft was displaced. All of the patients were followed at least until there was radiographic evidence of fusion (15 patients) or until a reoperation was performed (one patient). The average duration of follow-up was 37 months (range, 12--108 months).

7. Ecker ML and Lotke PA: Osteonecrosis of the medial part of the tibial plateau. *J Bone Joint Surg* 77:596--601, 1995.

Abstract: Fifteen elderly patients (16 knees) were seen because of acute pain in the knee and tenderness to palpation over the medial aspect of the tibial plateau. Initially, plain roentgenograms showed a radiolucent area at the site of the tenderness in only nine of the 16 knees. However, radionuclide bone scans showed focal increased uptake at the site of the tenderness in four of the seven remaining knees, and magnetic resonance images showed discrete areas of low signal intensity at the same site in the other three knees. Plain roentgenograms eventually showed the typical lesion in all knees. Progression of the symptoms led to a total knee arthroplasty in nine knees and to a unicompartmental replacement in three; a satisfactory result was obtained in all 12 knees. An operation was recommended for two other knees, but it was refused by the patients. The symptoms resolved spontaneously in the remaining two knees. A degenerative tear in the medial meniscus, which is a common finding in this age group, was noted at the time of a later operation in the three knees that had not had a radiolucent area on the initial plain roentgenograms but that had had an area of low signal intensity of the magnetic resonance images. If osteonecrosis of the tibial plateau is not considered as a potential cause of pain in the knee, symptoms may be attributed to a tear in the meniscus and an unnecessary and unproductive arthroscopy may be performed.

8. Steinberg ME, Hayken GD, and Steinberg DR: A quantitative system for staging avascular necrosis. *J Bone Joint Surg* 77:34--41, 1995.

Abstract: Much of the current confusion and contradiction on the treatment of avascular necrosis of the femoral head is caused by the lack of an agreed upon, efficient, quantitative system for evaluation and staging. We have used a new system to evaluate over 1000 hips with avascular necrosis during a period of 12 years; it has proved to be very valuable. The system is based on the sequence of pathological events known to take place. It allows accurate quantification in both early and later stages, does not use older, invasive diagnostic procedures, and incorporates the newer techniques of bone scanning and MRI. Clinical records of pain and reduced function are not a specific part of the system, although they help to determine treatment and outcome. Hips are first placed into one of seven stages from 0 to VI, based upon the type of radiological change. The extent of involvement is then measured. This allows more accurate evaluation of progression or resolution and better comparison of different methods of management. The system also helps to provide a prognosis and to decide on the best available method of treatment.

9. Esterhai JL, Jr, Sennett B, Gelb H, Heppenstall RB, Brighton CT, Osterman AL, LaRossa D, Gelman H, and Goldstein G: Treatment of chronic osteomyelitis complicating nonunion and segmental defects of the tibia with open cancellous bone graft, posterolateral bone graft, and soft-tissue transfer. *J Trauma* 30:49--54, 1990.

Abstract: Forty-two consecutive patients with chronic osteomyelitis complicating persistent tibial nonunion and chronic osteomyelitis complicating tibial fracture with segmental bone loss were treated from January 1979 through December 1986 using a protocol including either open cancellous bone grafting (Friedlaender-Papineau technique), posterolateral bone grafting (Harmon technique), or local or microvascular soft-tissue transfer before cancellous bone grafting. Each patient had undergone surgical debridement and intravenous antibiotic therapy before inclusion in this study. Patients were classified using a staging system which included consideration of anatomic location of the infection within the bone; extent of bone involvement; quality of soft-tissue envelope and vascular integrity; and generalized host status. The overall success rate for arresting the osteomyelitis and healing the nonunion was 62% (26/42). If the six patients who refused additional bone graft surgery, the one patient who represented poor patient selection, and the patient who refused ankle arthrodesis are eliminated, the success rate for healing of the nonunion and resolving the osteomyelitis in this difficult patient population is: open bone cell graft, 66% (12/18); soft-tissue transfer 87.5%, (7/8); and posterolateral bone grafting, 87.5% (7/8). Use of a standardized classification system allows comparison of treatment results. Adequate debridement is crucial in treating osteomyelitis complicating established long bone fractures and nonunions. Determining the extent of debridement has proven to be the single most difficult aspect technically. Patient selection and pretreatment education are crucial. Caring for these patients is not only labor intensive and demanding of personnel and hospital resources, but demanding of the patients as well.

10. Heppenstall RB, Sapega AA, Scott R, Shenton D, Park YS, Maris J, and Chance B: The compartment syndrome. An experimental and clinical study of muscular energy metabolism using phosphorus nuclear magnetic resonance spectroscopy. *Clin Orthop* 226:138--155, 1988.

Abstract: In an experimental ischemic compartment syndrome in dogs, phosphorus (^{31}P) nuclear magnetic resonance (NMR) spectroscopy was used to determine the tissue pressure threshold at which resting skeletal muscle begins to use anaerobic energy sources due to insufficient cellular oxygen delivery. The interactive effects of systemic perfusion pressure and moderate muscle trauma on this anaerobic threshold were also evaluated. The severity of cell injury produced by various degrees of compartment pressurization over an eight-hour period was concomitantly studied using muscle biopsy and electron microscopy. Clinical correlation of a preliminary patient series studied using ^{31}P -NMR demonstrated that the threshold for cellular metabolic derangement in skeletal muscle subjected to increased tissue pressure was more closely associated with the difference between mean arterial blood pressure (MABP) and compartment pressure than with the absolute compartment pressure alone. The difference is termed MABP-compartment pressure, or Delta P. The lowest Delta P at which a normal cellular metabolic state can be maintained is approximately 30 mmHg in normal muscle and 40 mmHg in moderately traumatized muscle. It is imperative to interpret compartment pressure measurements in light of the degree of soft tissue trauma sustained and the patient's blood pressure, as well as the clinical signs and symptoms.
