What's New in Orthopaedic Rehabilitation

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Orthopaedic rehabilitation is a unique subspecialty of orthopaedic surgery that focuses on improving the functional outcome for individuals with musculoskeletal disability with use of surgical and nonsurgical management. Orthopaedic rehabilitation focuses on the musculoskeletal system as a whole as well as on the linkages and couplings between bones, joints, muscles, and the nervous system. This subspecialty encompasses patients of all ages, a broad range of anatomic locations, and a variety of musculoskeletal dysfunctions. Orthopaedic rehabilitation comprises all of the traditional orthopaedic subspecialties, including amputation surgery, prosthetic and orthotic management, neuromuscular diseases, and the variety of neurologic disorders that defy easy classification.

The current report highlights presentations and advances in several areas of orthopaedic rehabilitation that were discussed at meetings of the Orthopaedic Rehabilitation Association, the American Academy of Orthopaedic Surgeons, and other subspecialty organizations over the past year. The review also highlights the papers that received the Jacqueline Perry Award and the Vernon Nickel Award, the two prestigious awards in orthopaedic rehabilitation that are presented annually by the Orthopaedic Rehabilitation Association.

Gait Analysis and Dynamic Electromyography

Gait analysis is an important tool that is used to understand the complexities of movement and lower extremity function. Such a detailed description of function has been valuable for determining both nonoperative and operative management guidelines for individuals with abnormal gait patterns. In a study of patients with spastic paresis of the lower extremity, Kerrigan and Glenn showed that reduced knee flexion was secondary to dynamic ankle plantar flexor weakness rather than spastic quadriceps activity, as previously thought. Dynamic polyelectromyography has a proven role in the clinical assessment of gait and the subsequent planning for the surgical treatment of both upper and lower extremity neuromuscular disorders. Its use is not limited to research questions alone. Keenan, Romanelli, and Lunsford performed a dynamic polyelectromyographic analysis of grasp and release in forty-two patients with a brain injury associated with spasticity of the hand and wrist. They noted that fourteen muscles had out-of-phase activity that could not be detected on the basis of a clinical examination alone. Keenan, Haider, and Stone utilized dynamic poly electromyography to direct the surgical planning for forty-five elbows in adults with a traumatic brain injury. They noted that dynamic poly electromyography revealed a similar pattern of muscular activity in their patients, especially in the brachioradialis and biceps muscles. They concluded that elbow flexor spasticity in these two muscles hindered correct hand placement and found that subsequent selective lengthening of these muscles improved control and movement. Keenan and Mehta used dynamic poly electromyography to help guide their surgical decision-making in the treatment of shoulder dysfunction in patients with both neurogenic and mechanical shoulder problems. Etnyre et al. concluded that preoperative gait analysis helped surgeons plan for the surgical correction of equinus gait in children with spastic cerebral palsy. Fuller et al. highlighted the importance of preoperative dynamic poly electromyography in the treatment of spastic equinovarus deformity of the foot and ankle. When dynamic poly electromyographic data were used to assist in operative decision-making, well over half the initial plans for surgical intervention were modified. Therefore, it is reasonable to conclude that dynamic poly electromyography provides an invaluable tool for surgical decision-making in the treatment of upper and lower extremity neuromuscular disorders.

Amputation Surgery and Prosthetics

It has been common orthopaedic teaching that a more distal amputation level generally results in better function. Although this concept is intuitive, scientific studies have helped sur-
Heterotopic Ossification

Heterotopic ossification, defined as the formation of normal bone in abnormal locations, is a process that is associated with both common orthopaedic conditions such as total hip arthroplasty and uncommon genetic conditions such as fibrodysplasia ossificans progressiva. Unfortunately, as is the case with the formation of normal bone in the axial and appendicular skeleton, little is known about the underlying cellular and molecular mechanisms involved in heterotopic ossification.

The link between brain and bone is evident in many disease processes that result in heterotopic ossification. The prevalence of clinically important heterotopic ossification is between 10% and 20% in patients with central nervous system injuries. Approximately 10% of patients with a traumatic brain or spinal cord injury experience severe restriction in joint motion or ankylosis as a result of heterotopic ossification. In one study, heterotopic ossification of the elbow joint developed in >90% of patients who had sustained a traumatic brain injury along with a fracture-dislocation of the elbow.

Unfortunately, because of the level of unresponsiveness in patients with central nervous system injuries, fractures may go undetected in these patients. Garland and Bailey reported undiagnosed fractures in 11% of adult patients with head injuries. The rate of undiagnosed fractures is reportedly greater in children and was found to be as high as 40% in one study.

Some physicians have recommended guidelines to help decrease the rate of missed fractures during the early management of multiply injured patients. Kushwaha and Garland recommended screening plain radiographs of the cervical spine, thoracolumbar spine, and pelvis for all patients with central nervous system injuries. They also advised that radiographs of the knee should be made for patients who have been involved in a pedestrian-automobile accident, that a whole-body bone scan should be performed for skeletally immature patients, and that electromyographic and nerve-conduction studies should be performed for patients who are suspected of having clinical signs of neuropathy.

At a molecular level, the formation of heterotopic bone requires three biological components: an inducible signaling pathway, osteoprogenitor cells, and an environment conducive to osteogenesis. Although much information has been gained regarding the signaling pathways required for normal bone formation in developmental processes, little is known about the formation of bone in the adult model. With the exception of fracture-healing in animal models, normal bone formation remains a perplexing process.

As early as 1965, Urist and many others began the search for processes responsible for the formation of bone. After decades of research, recent advances in molecular biology have helped to elucidate the molecules and signaling pathways involved in bone formation. Besides the strong and proven role of bone morphogenic proteins (BMPs) in inducing bone formation, the overexpression of osteocalcin, type-1 collagen, and osteonectin all have been implicated in the formation of heterotopic as well as normal bone.

Perhaps the most clinically relevant search for the molecules responsible for bone induction and formation can be found in the spine fusion model. Because of the importance of establishing a solid fusion mass as well as the morbidity associated with the harvesting of autogenous bone graft, alternative substitutes—both biological and synthetic—have been advocated for their osteoinductive as well as their osteoconductive properties. Although studies of rabbits, dogs, and nonhuman primates have established the efficacy of BMPs in augmenting spinal fusion, human studies in the United States have not been very promising.
Orthopaedic Care of the Elderly Patient

Each day, 6000 Americans reach the age of sixty-five years. From 1950 to 2000, the elderly population (that is, individuals who are sixty-five years of age and older) grew twice as rapidly as the total resident population of the United States. There are currently 35 million people in the United States who are sixty-five years of age or older. Musculoskeletal diseases and symptoms are the second leading reason why seniors visit their physicians or are admitted to hospitals.

Osteoarthritis is very common, affecting more than 40 million Americans. The prevalence of osteoarthritis increases with age, and an estimated 70% of Americans over the age of sixty years are affected. Primary and secondary osteoarthritides have distinct differences, but the overall picture remains the same. Risk factors such as smoking, obesity, gender, ethnic background, and genetic predisposition all play roles in diagnostic and treatment protocols.

Osteoporosis is a complex issue with multiple manifestations. Age-related changes in bone and soft tissue frequently are associated with disabling fractures. The diagnosis of osteoporosis is based on a measurement of bone mineral density. Osteoporosis affects approximately 20 million Americans, and 1.2 million fractures are attributed to this condition each year. It has been estimated that one-half of all women over the age of fifty years and one-third of all men over the age of seventy-five years will sustain an osteoporosis-related fracture. Approximately two-thirds of patients who sustain a fracture of the hip do not return to their prefracture level of function.

Hip fractures are considered to be the most debilitating fractures in the elderly population. Currently, 250,000 to 300,000 hip fractures occur annually in the United States, with the mortality rate ranging from 14% to 50% within the first year after the injury. While the incidence of high-velocity trauma (for example, injuries resulting from motor-vehicle accidents) has been on the rise in the elderly population, most of these fractures are still the result of low-velocity injuries, usually secondary to a fall.

The mortality rate associated with peritrochanteric fractures is comparable with that associated with femoral neck fractures. Currently, the use of extramedullary as opposed to intramedullary devices is being debated. Extramedullary implant options include a sliding hip-screw with a side-plate and fixed-angle devices. The screw and side-plate currently is the standard of care for most stable intertrochanteric hip fractures.

Intramedullary devices utilize the familiar concept of the sliding hip-screw but couple it with an intramedullary rod rather than a femoral buttress plate. Intramedullary devices are subject to smaller joint-reactive forces because they are placed more medially in the femoral canal and therefore are subjected to more favorable biomechanical conditions. These implants recently have become more popular, with good results having been reported following the treatment of the challenging reverse obliquity fracture as well as unstable intertrochanteric fractures. The appeal of a minimally invasive technique and full early weight-bearing are attractive incentives for their use. Complications usually are secondary to malreduction in varus alignment and posterior sag. As with extramedullary devices, fracture stability is the key to proper surgical fixation with use of an intramedullary implant.

Investigators at some centers have been comparing the benefits of primary total hip arthroplasty with those of unipolar or bipolar arthroplasty for the treatment of displaced femoral neck fractures in elderly patients. Currently, unipolar or bipolar hemiarthroplasty is the standard of care for patients without evidence of acetabular degenerative disease.

Many distal femoral fractures can be treated with intramedullary devices, with the proximal interlocking screws being used to capture the fracture fragments. Intra-articular fractures usually are best treated with plates and screws. Newer implants, such as locking plates, are attractive and offer biomechanical advantages over traditional plates and screws, but they are still new devices without an established clinical track record. Early results, however, have been promising.

The Jacqueline Perry Award Paper

Outcomes of Surgical Treatment of the Spastic Shoulder

Surgical treatment of shoulder contractures following upper motor neuron dysfunction has been limited to complete operative release of the muscles, tendons, and capsule about the shoulder joint or denervation by means of neurectomy. This rudimentary approach to shoulder contractures does not differentiate between active and passive contractures about the glenohumeral joint. Mehta et al. found that approximately 4% of patients with upper motor neuron disease experience considerable limitation of shoulder function. In their study of 742 patients with upper motor neuron problems, they found that twenty-five patients qualified for surgical treatment. They divided their patients into two groups: those with active dysfunction and those with passive dysfunction. For patients with active dysfunction, dynamic electromyography and clinical evaluation were used to help determine the selective surgical lengthenings necessary to improve the overall range of motion of the shoulder. For patients with passive dysfunction, a complete contracture release was necessary, including releases of the pectoralis major, latissimus dorsi, and teres major muscles. The authors concluded that while the traditional tendon releases were a reasonable treatment option for patients with...
static deformities, more selective surgical lengthenings, based on dynamic electromyography and clinical evaluation, were warranted for patients with active shoulder contractures due to upper motor neuron dysfunction.

The Vernon Nickel Award Paper
The Role of Patient Restrictions in Early Dislocation Following Total Hip Arthroplasty

In a prospective, randomized clinical trial designed to evaluate the role of patient restrictions, Peak et al. found that removal of traditional restrictions did not increase the incidence of early dislocation following total hip arthroplasty performed through an anterolateral approach. This study suggested that the traditional precautions have been thought to decrease the rate of dislocation following total hip arthroplasty through a posterolateral approach, no data have suggested that they also decrease the rate of early dislocation following the use of an anterolateral approach. This study suggested that the traditional hip restrictions used for the posterolateral approach to the hip have no significant impact on the rate of early dislocation in patients managed with total hip arthroplasty through an anterolateral approach. Similar findings also were reported in a nonrandomized, prospective clinical study.1

Overview
Orthopaedic rehabilitation covers a wide range of topics involving almost every segment of the orthopaedic surgical population. From initial evaluation to postoperative care, an understanding of the most useful diagnostic tests as well as surgical and nonsurgical orthopaedic rehabilitation options will greatly facilitate clinical decision-making and treatment.

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