What's new in orthopaedic surgery? A review of major breakthroughs and advances in orthopaedics

CLINTON S. BELL, MD, AND ROBERT W. JACKSON, MD • Department of Orthopaedic Surgery, BUMC

Tremendous advances have been made in orthopaedic surgery since its inception over 250 years ago. Although subspecialties such as spinal surgery, orthopaedic oncology, and hand surgery have made significant technological and biological advances in the past 40 years, 3 broad areas have significantly influenced the quality of care that orthopaedists are able to provide to patients with musculoskeletal ailments. This article describes the evolution of the field of orthopaedics, emphasizing the development of arthroscopic surgery, modern joint replacement, and the open reduction and internal fixation of fractures.

Orthopaedic surgery, like most medical and surgical specialties, has undergone tremendous technological growth over the past few decades. Treatments that are commonly used today were once looked upon with skepticism and disbelief by many leading physicians. However, as with any great change or discovery, testing and use over time has ultimately revealed those treatments that are truly beneficial. Indeed, through ingenious ideas are born treatments that improve upon already established methods. It is in this way that the practice of medicine has evolved and will continue to improve as we sit poised to enter the 21st century.

The specialty of orthopaedic surgery, in particular, has grown rapidly in the past 40 years, and today it provides medical, surgical, rehabilitative, and orthotic care to a diverse group of patients. This rapid progress has dramatically improved the quality of life for children and adults with painful and disabling conditions that affect the musculoskeletal system. Today's orthopaedist is capable not only of surgically correcting many musculoskeletal problems, but also treating, by a variety of means, virtually every aspect of musculoskeletal disease.

FROM HUMBLE BEGINNINGS

In the beginning, orthopaedics had a much more focused scope than it has today. In 1741, Nicolas Andry, a professor of medicine at the University of Paris, differentiated orthopaedics from other medical and surgical specialties in his book L'Orthopedie. For the title, Andry derived the word orthopaedic from the Greek words orthos, meaning straight or free from deformity, and paidion, meaning child. A few years later, the book was published in English, Belgian, and German editions, thereby helping to spread Andry's approach to treating deformities in children and the use of the term orthopaedic (1).

In his book, Andry's focus was not the surgical treatment of musculoskeletal problems or the treatment of traumatic injuries of the musculoskeletal system. Instead, his emphasis was on the
value of moderate exercise and muscle strengthening to improve general health and musculoskeletal function. Because of his understanding of the effects of growth and of changes in loading and use upon the musculoskeletal system, he was able to advise the use of manipulation, splinting, and active exercise to prevent and treat deformities (2). In fact, the theme of his book is easily inferred by noting the words added to the title of the English edition—Orthopaedia: or The Art of Correcting and Preventing Deformities in Children.

Following the publication of Andry's book, many discoveries and improvements in orthopaedic care were made, and, over the years, evolving developments have continued to refine and advance the scope of orthopaedic surgery. Certainly important was the advent of anesthesia and antisepsis. These breakthroughs made it possible to carry out the surgical correction of musculoskeletal deformities humanely, thus making this relatively new treatment feasible. Roentgenography, discovered late in the 19th century, gave orthopaedists the ability to visualize bony abnormalities and the results of treatments. They discovered that techniques such as surgical osteotomy could correct deformities of the long bones and restore motion in patients with stiff hips by creating pseudoarthroses. Arthrodesis could correct joint deformity and help relieve painful arthritic joints in patients debilitated by such conditions. Later, orthopaedic surgeons developed the knowledge and ability to transplant bone from one part of the body to another to help effect fracture healing. Also, the concept of transplantation was extended to tendons that could be transplanted to healthy muscles to restore the functional deficit created by paralyzed muscles (2).

Most of these procedures were originally used on children, but the same procedures were found useful on adults as well. By the outbreak of World War I, the areas of pediatric and adult orthopaedics were well established. With the multitude of injuries incurred as a result of the war, treatment of orthopaedic trauma became another area of expertise for the orthopaedist. Since then, advances in the treatment of other musculoskeletal problems have continued and have further diversified the field of orthopaedic surgery.

Since the publication of Andry's book more than 250 years ago, many advances in the treatment of musculoskeletal ailments have helped create orthopaedics as it exists today. No longer concerned only with the nonsurgical treatment of childhood deformities, today's orthopaedic surgeon is involved with the diagnosis and the surgical and nonsurgical treatments of musculoskeletal diseases and injuries affecting bone, cartilage, muscle, ligament, tendon, nerve, and vessel in patients of all ages. Orthopaedics is no longer simply a mere interest shared by a select group of medical professionals. It is now a specialty of its own with its providers proficient in all aspects of musculoskeletal care. Regions of the body involved in orthopaedic care include not only the limbs, but also the shoulders, pelvic girdle, and spine. Orthopaedic treatment involves medical, surgical, rehabilitative, orthotic, prosthetic, and physical methods, such as manipulation, bracing, and splinting (2). In the past, orthopaedists focused on the treatment of conditions such as poliomyelitis, tuberculosis, osteomyelitis, bone setting, and birth defects. Some of these conditions have been eliminated. Others are diagnosed earlier and treated more effectively. Areas of particular interest for today's orthopaedic surgeons include joint replacement, arthroscopic surgery, sports medicine, fracture care, and microsurgery, to name only a few.

Several advances within the field of orthopaedic surgery in the past 40 years have contributed greatly to the evolution and current state of orthopaedics. Continued improvement in these and in
all areas of orthopaedic surgery is, of course, desirable and inevitable and surely will improve the quality of care given to the orthopaedic patient.

MAJOR ADVANCES IN ORTHOPAEDICS

Minimally invasive surgery: arthroscopy

Perhaps one of the most significant advances to occur in orthopaedic surgery has been the addition of arthroscopic surgery, a minimally invasive technique. Prior to the introduction of endoscopic techniques, large incisions had to be made in order to obtain the surgical exposure needed to treat problems. As a result of the surgical exposure, postoperative, and occasionally persistent, morbidity was common. Surgeons and their patients were forced to weigh the possible benefits of proposed elective surgery against the damage inflicted by the procedure. It was not uncommon that elective surgeries were performed as a last resort, after being postponed until symptoms were either sufficiently great or persistently present to warrant operating. With the introduction of endoscopic techniques came the ability to diagnose problems and even treat them without the subsequent morbidity that had accompanied many prior procedures. Recuperative time was greatly reduced. Because problems were frequently addressed at an earlier stage before the pathology had a chance to advance, results of operations were more likely to be successful.

Arthroscopy and similar modern endoscopic techniques used in surgical disciplines other than orthopaedics owe their origins to the pioneers of cystoscopy. In 1806, Philip Bozzini presented the first known endoscopic device to the Joseph Academy of Medical Surgery in Vienna. Its intended use was for the visualization of the interior of the urinary bladder. The apparatus was not well received. Although minor advances in endoscopic technology occurred over the following years, several decades and several major technological discoveries would be required to prove the true usefulness of an endoscope to the medical community. Probably the 2 most significant breakthroughs that helped establish the early cystoscope as a valuable instrument were the discovery of the incandescent light bulb by Thomas Edison and improvements in the field of optics (3).

The first known applications of endoscopy to the musculoskeletal system occurred in Japan in 1918 when Professor Kenji Takagi used a cystoscope to examine the knee joint. Two years later a Swiss physician, Eugen Bircher, independently used a laparoscope for the same purpose. For many years, arthroscopy, or arthroendoscopy as it was known in the early days, was used more as a toy than as a valuable surgical instrument (3). Continued refinement of the arthroscope and continued interest by pioneers involved in its development culminated in the publication of the first atlas of arthroscopy in 1957 (4). By the time of its publication, only a few Americans had experimented with arthroscopy. In 1965, however, the technique was reintroduced to North America by Dr. Robert W. Jackson, who performed 25 arthroscopies that year. After a period of initial reluctance, arthroscopy has become one of the most commonly performed operative orthopaedic procedures in the world, with over 1 million arthroscopies being performed in the USA last year. This increased use has been due in part to several recent developments that helped expand arthroscopy's role and possibilities. Notable are the development of fiberoptic lighting systems, the use of miniaturized color cameras to show on monitors the view of the interior of the joint, and the increased interest by instrument companies to design and manufacture improved instruments (Figure 1).
Arthroscopic surgery has revolutionized the approach to and treatment of joint disorders. Today, arthroscopy is performed on virtually all major joints of the body, and, because of its applications, the world has gained a greater understanding of joint mechanics, anatomy, and function. Its use continues to serve a vital role in the diagnosis and treatment of musculoskeletal ailments because of its high degree of clinical accuracy, low morbidity, infrequent complications, and quick recovery time. Additionally, the development and increased use of arthroscopic techniques have played major roles in the ability to perform surgical procedures on an outpatient basis, thereby saving money and resources.

Arthroscopy will continue to be a major surgical modality used by orthopaedic surgeons. Its great success has spawned the endoscopic revolution that is occurring in most surgical disciplines. The possibilities for endoscopic treatments of the future are limited only by the imagination and ingenuity of today's surgeons and developers. It is likely, if history is any guide, that further advances are sure to be made that will improve the applications of this minimally invasive technique even more.

**Adult reconstructive surgery: joint replacement**

Thirty-eight years ago Sir John Charnley developed a revolutionary new procedure involving the total reconstruction of a patient's arthritic hip using a nonhinged, cemented, metal and polyethylene prosthesis. A decade later, Insall and others adopted similar principles of artificial arthroplasty and applied them to the knee (5). Prior to these technologies, the methods used by orthopaedists to treat severe arthrosis of the major weight-bearing joints were unreliable and either unsuccessful in relieving pain or not durable.

Before the advent of total joint arthroplasty, patients with significant arthritis of the hip or knee were often forced to endure their pain, with only minimal relief obtained by analgesic medications and other conservative treatments. If these modalities failed to provide sufficient relief of the discomfort, or if limited function in the joint created marked disability, surgical procedures such as arthrodesis or the establishment of a pseudoarthrosis were essentially the only durable surgical options; these procedures, however, resulted in significant disabilities in their own right. Another surgical option at that time, weight-transferring osteotomy, was occasionally successful in relieving pain, but the relief was usually only temporary and was often incomplete. Furthermore, osteotomy was not even an option for patients with severe joint disease (6). With the advent of total joint arthroplasty, there finally was available a surgical option that could provide lasting and reliable relief of pain and functional improvement in these patients.

Total joint arthroplasties of the hip and the knee have been received with much enthusiasm by the orthopaedic community because of their ability to relieve pain and restore function. The ideas and techniques initiated by the pioneers of joint replacement have given orthopaedic surgeons the power to improve patients' lives irrevocably and have forever changed the surgical treatment of arthritic joints.

Adult reconstructive surgery, which includes the surgical treatment of joints badly affected by degenerative or rheumatic disease, has expanded into one of the largest and most successful areas of orthopaedic surgery. Over 500,000 arthroplasty implants are placed into knees and hips annually...
in the USA alone. Implant survival rates at 20 years are 93% for total knee replacements and 86% for total hip replacements (7). In addition, because of the success of arthroplasties of the hip and the knee, procedures and equipment have been designed to replace joints in other parts of the body. Humeral head replacement is now a dependable method for restoring comfort and function in patients with acute or old comminuted fractures of the proximal humerus. Ankle and elbow arthroplasty and replacement of the small joints of the hand are other areas of interest among many orthopaedic surgeons.

Since the introduction of joint replacement, improvements in prosthetic materials and design and advances in the technical aspects of surgery have reduced the occurrence of many of the problems that were associated with early implants. Today, total joint arthroplasties of the hip and the knee are among the most successful surgical procedures performed by any specialty, with marked relief of pain and improved joint function in the majority of patients treated (Figure 2). Total joint arthroplasty is a cost-effective procedure that significantly improves a patient's quality of life and mobility. Undoubtedly, continued follow-up of treated patients and continued refinement of the techniques of arthroplasty and the design of the implants will improve these already successful operations.

**Improved fracture management: open reduction and internal fixation**

During the past few decades, there have been significant advances in the way orthopaedists treat fractures. Consequently, fractures are now healing more dependably and with less residual deformity than ever before. Patients treated for orthopaedic trauma are more likely to subsequently lead normal lives without significant disability. These improvements are due in large part to the philosophy of fracture treatment enunciated by the Arbeitsgemeinschaft für Osteosynthesefragen/Association for the Study of Internal Fixation (AO/ASIF), an organization established in 1958 by a group of Swiss orthopaedic and general surgeons (8).

The original goal of the AO/ASIF group was to improve upon the contemporary methods of fracture treatment in Switzerland (8). Before the establishment of this group, open reduction and internal fixation of fractures were uncommon. Instead, fracture management most often involved prolonged immobilization, with bed rest and traction often being used for severe injuries to the lower extremities. Although this method of treatment usually resulted in union of the fracture, poor functional results were common among those treated. The AO/ASIF, recognizing that the ultimate goal of fracture treatment is complete and early recovery of limb function, set out to produce a system of techniques, implants, and instruments to improve the functional outcome of their patients (9). The results of this effort have been truly striking. Now, more people than ever are recovering after sustaining orthopaedic trauma, with less residual functional impairment.

One of the initial accomplishments of the AO/ASIF was the conception of 4 treatment principles that are still valid today. The first principle stresses the importance of obtaining an anatomical reduction of the fracture fragments, especially when the fracture extends into the joint (9). If closed methods of reduction prove inadequate, open reduction of the fragments by surgical means is carried out. Anatomic reduction is desired to prevent the development of posttraumatic arthrosis and to improve the chances of having a long-lasting and fully functional joint.
The second principle is an extension of the first. After obtaining a good reduction of the fracture fragments, it is necessary to achieve stable fixation of the fragments to maintain the proper anatomic shape. This can be accomplished by a variety of methods ranging from external splints, such as plaster fixation, to internal fixation by plates, screws, wires, and intramedullary nails. Also included are transcutaneous splints—the so-called external fixators (9). Success of the modern fixation techniques over the past several decades has spawned substantial interest by equipment and instrument manufacturers to develop fracture stabilization equipment.

The third principle is an important concept that has been increasingly recognized as a critical element for proper fracture healing. The preservation of the blood supply to the bone fragments and the soft tissue by means of atraumatic surgical techniques is vital in maintaining adequate nutrition to the fragments and preventing bone necrosis (9). Understanding of this simple concept is due in large part to the greater efforts of basic science researchers directed at the study of osteosynthesis.

The fourth principle, early and pain-free mobilization, emphasizes the desire for early postoperative motion of the muscles and joints adjacent to the fracture (9). This concept was contrary to the opinion of the time—that prolonged immobilization was necessary for proper fracture healing to occur. The primary reason for advocating early, protected mobilization is that early motion prevents many of the undesirable sequelae that had, at that time, been accepted as unavoidable with the treatment of fractures. Problems, such as stiff joints, marked muscle atrophy, and osteoporosis, were common following immobilization, and more troublesome complications, such as pneumonia, decubitus ulceration, and deep vein thrombosis, were due in large part to prolonged recumbency. The move from an era in which prolonged immobilization was the mainstay of treatment to today's emphasis on early motion and rehabilitation has improved, without compromise, fracture healing and posttraumatic musculoskeletal function.

The AO/ASIF itself continues its role in the development of its principles, techniques, implants, and instruments by the close collaboration of research and practical surgical work. Its methods of knowledge acquisition and dissemination and the magnitude of the work it has accomplished have been astounding and the improvements made in fracture treatment immeasurable.

**Other advances**

The major advances discussed above, i.e., arthroscopic surgery, joint replacement, and open reduction and internal fixation of fractures, have revolutionized the practice of orthopaedic surgery as a whole, but by no means do we intend to imply that the list is comprehensive or that it represents the extent of improvement and development that has occurred in recent times. Indeed, great advances have been made within all the subspecialty areas of orthopaedics.

Sports medicine has recently made great strides in the treatment of shoulder and knee pathology. An improved understanding of shoulder and knee mechanics has led to treatment strategies that are more likely to result in return of the athlete to sports. Procedures such as capsular shrinkage to stabilize the shoulder and arthroscopic reconstruction of the anterior cruciate ligament and partial meniscectomy in the knee are achieving this goal and hopefully resulting in long-term preservation of joint function. The subspecialty of hand surgery has acquired a valuable tool with the development of microsurgical techniques to perform technically challenging procedures such as
nerve and small-vessel repair. Truly remarkable is the ability of surgeons, with the aid of an operating microscope, to reimplant a patient's severed hand or arm with good recovery of limb function.

Spinal surgery has also seen great improvements recently. Minimally invasive disc surgery and enhanced spinal fusions for degenerative disorders are significant advances. Spinal instrumentation, i.e., implantable devices used in the surgical treatment of spinal disorders, has been developed and can significantly correct spinal deformities that were previously untreatable. Likewise, rigid spinal fixation by the pedicle screw and other devices and advances in the techniques of vertebrectomy have improved the treatment of cancer patients with spinal metastases or patients with infection. Often, these treatments can result in significant pain relief and neurological recovery.

In pediatric orthopaedics, one of the major areas of progress has been the greatly improved treatments now available for patients diagnosed with malignant bone tumors. These treatments have resulted in the increased survival of many patients whose diagnoses previously carried grave prognoses. Defects created by tumor resection are treated more effectively as well. Techniques such as distraction osteogenesis and bone transport now are used in the reconstruction of these bone defects and in cases in which significant trauma or infection has resulted in deformity. These relatively new technologies, originally used to correct limb length discrepancies in children, can dramatically correct limb deformity and restore function (10).

Today, orthopaedic researchers strive to improve orthopaedic treatment modalities through better understanding of the composition, structure, and function of musculoskeletal tissues (2). Much knowledge has been gained in the past few decades regarding disease processes, such as rheumatoid and degenerative arthritis, and the body's response to injury. Additionally, the areas of biomechanics and biomaterials have helped create the implants and prostheses that are now an integral part of orthopaedic surgery. Research will continue at a never-before-seen pace and will certainly improve the understanding and treatment of musculoskeletal problems.

Finally, it would be wrong for medical specialists today, especially orthopaedists, not to mention the contribution of diagnostic radiology in regard to diagnostic decision making. Computed tomography and magnetic resonance imaging have found a niche in orthopaedics and are likely to remain as useful diagnostic tools.

**CONCLUSION**

The demand for orthopaedic services is at an all-time high. With the continued aging of the US population, the demand is likely to increase even more. For example, the orthopaedic service is now the busiest surgical service at Baylor, both in numbers of patients treated and in operating room use. Orthopaedists now have a better understanding of the multitude of problems that affect the musculoskeletal system and, accordingly, are better able to treat these problems. Let us as physicians not be lax in our continued pursuit of an improved understanding of disease and injury and of superior methods of treatment. Perhaps in another 40 years, the accomplishments mentioned in this article will seem trivial compared with the state of orthopaedics at that time.
References


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Figure 1

Figure 2