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Valuation of Orthopedic Services: Technological Advancements

Prior installments of this five-part Health Capital Topics series on the valuation of orthopedic services examined the competitive landscape, reimbursement trends, and the regulatory environment of the orthopedic specialty. This fifth and final installment examines the technological advancements affecting orthopedic services, including developments in robotic surgery, arthroscopy, diagnostic imaging, 3D printing, and artificial intelligence (AI).

Minimally Invasive Surgery

Minimally invasive surgical procedures allow physicians to provide services in a manner that causes less disruption to the patient than a traditional surgical method that requires larger incisions, causing less pain and reducing recovery time.[1] For certain high-risk patients, such as individuals with comorbidities, minimally invasive procedures may offer favorable outcomes compared to traditional surgery, including shorter hospital stays, less postoperative bleeding, and lower wound infection rates.[2] As the technology and training associated with minimally invasive surgery has advanced, it has been utilized to perform some of an orthopedic surgeon's defining procedures, including knee arthroscopy, knee replacements, and spine surgery.

There are two primary types of minimally invasive surgery. Non-robotic, endoscopic (also referred to as laparoscopic) surgery involves the physician performing the specified procedure through one or more incisions using small surgical instruments and video cameras. Robotic surgery utilizes small robotic arms equipped with surgical instruments, which the physician controls via console controllers while viewing a high-definition, 3D image on the console.

Robotic-Assisted Surgery

Approximately 25% of U.S. orthopedic operating rooms now have access to a robotic platform, with all four major device manufacturers offering systems across knee, hip, spine, and shoulder applications.[3] Robotic surgery is often used for partial and total joint replacements. The American Joint Replacement Registry's (AJRR) 2024 Annual Report found robotic assistance was used in 15.9% of primary total knee arthroplasty (TKA) procedures in 2023, an eight-fold increase from 2017, and in over 6% of primary total hip arthroplasty (THA) procedures.[4] The technology is designed to improve the accuracy and precision of implant placement in a manner that is difficult to reproduce manually and may lead to faster recovery, improved clinical outcomes, and fewer revisions, though evidence on long-term outcomes continues to evolve.[5] As a result, the implementation and utilization of robotic assistance may improve reimbursement due to fewer readmissions and a faster recovery period.

Recent developments have significantly expanded the scope of robotic-assisted orthopedic surgery. Stryker's Mako platform received U.S. Food & Drug Administration (FDA) clearance for spine applications in May 2024 and shoulder applications in November 2024, extending its coverage to total knee, partial knee, total hip, spine, and shoulder procedures.[6] Zimmer Biomet's ROSA Shoulder, cleared in February 2024, became the world's first robotic surgical assistant for shoulder arthroplasty.[7] The company further completed a $177 million acquisition of Monogram Technologies in October 2025 to integrate semi-autonomous and fully autonomous robotic capabilities into its platform.[8] Johnson & Johnson's VELYS platform received FDA clearance for spine applications in August 2024 and commercially launched at the American Academy of Orthopaedic Surgeons (AAOS) 2025 Annual Meeting; the VELYS system also received FDA clearance for unicompartmental knee arthroplasty in June 2024, with the first U.S. cases performed in December 2024.[9]

Arthroscopy

Arthroscopy is a minimally invasive surgical technique that allows orthopedic surgeons to see inside a joint, so the surgeon can more accurately determine the amount or type of injury, correcting the problem if necessary. To perform an arthroscopic surgery, the orthopedic surgeon creates a small incision through which an arthroscope is inserted, which employs a fiber optic lighting system to illuminate the structures of the joint.[10] The arthroscope displays the image on a screen, allowing the surgeon to view the joint without exposing the entire area. While diagnosing joint injuries or diseases are typically initiated through medical history, physical examination, and diagnostic imaging, with arthroscopy, a final, more accurate diagnosis may be made.

Some therapeutic procedures can also be performed arthroscopically, repairing or correcting the problem with minimal invasion. This technique stands in contrast to traditional surgery, which involves more invasive incisions. This minimally invasive method can reduce the recovery time for the patient and often requires little or

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no pain medication during recovery. Most patients undergo this surgical technique on an outpatient basis and are home within several hours after completion.[11] As the technology and relevant techniques improve, orthopedic surgeons will continue to perform more diagnostic and therapeutic procedures arthroscopically.

Artificial Intelligence in Orthopedics

AI integration in orthopedics has reached an inflection point. As of December 2025, the FDA had authorized 1,247 AI and machine learning (ML)-enabled medical devices, including a record 258 cleared in 2025 alone, with approximately 77% in radiology applications.[12] AI-based orthopedic imaging represents one of the fastest-growing market segments at a 34.6% compound annual growth rate, projected to reach $7.14 billion by 2029.[13] Recent FDA clearances demonstrate the expanding application of AI in orthopedics. In July 2024, Stryker's Q Guidance Spine 5 with Copilot became the first-to-market AI-assisted technology for bone resection and screw delivery.[14] The FDA published draft guidance in January 2025 on AI-enabled device software functions, signaling continued regulatory evolution for this rapidly advancing sector.[15]

Diagnostic Imaging

Advances in diagnostic imaging continue to enhance orthopedic diagnosis and treatment planning. X-ray, or radiography, utilizes small doses of ionizing radiation to produce images of the body's internal structures and remains a fundamental diagnostic tool. Computed tomography (CT) scans are often used to examine bones, muscles, fat, organs, or blood vessels. Unlike magnetic resonance imaging (MRI), CT scans use x-ray and computer technology to produce cross-sectional images. MRIs allow providers to noninvasively diagnose or monitor injuries or disorders of the spinal cord or joints. Unlike x-rays and CT scans, which use ionizing radiation technology, MRIs use a large magnet, radio waves, and a computer to create a cross-sectional image. An MRI may be more appropriate than a CT scan when organs or soft tissues are being studied, as an MRI scan is more capable of displaying the contrast between normal and abnormal soft tissues.[16]

3D Printing

3D printing technology continues to mature in orthopedic applications, with 81% of 3D-printed orthopedic implant studies utilizing titanium alloys.[17] In April 2024, 3D Systems received FDA clearance for the VSP PEEK Cranial Implant, the world's first 3D-printed polyether ether ketone (PEEK) cranial implant, representing continued expansion of additive manufacturing into patient-specific applications.[18] Rather than a subtractive process where a block of material is formed into the desired implant shape, 3D implants undergo additive manufacturing, created by adding material layer by layer. An advantage of utilizing custom implants is that they replicate the normal mechanics of a joint, better adapting to the patient.[19] Benefits include reduced operating time, decreased intraoperative blood loss, and improved clinical outcomes of surgical procedures.

Industry Outlook

Orthopedists will continue to be subject to multiple challenges in the coming years. These include rising demand for orthopedic services from an aging and increasingly unhealthy population, growing regulatory scrutiny and evolving reimbursement levels, and the high costs of implants and other new technologies. Additional factors related to the limited supply of orthopedic surgeons, driven by the aging orthopedic workforce and limited number of graduate education spots for orthopedists, may also affect the supply and the demand dynamic for orthopedic services in the future. In such an environment, successful orthopedic surgeons must be aware of these challenges and be able to adapt to any changes and difficulties in a way that controls costs and delivers high-quality care through the utilization of value-based models of care, care coordination, and advancing technology.

Technology adoption decisions carry significant capital implications. Robotic platforms require substantial investment but may be necessary for competitive positioning as market penetration continues climbing. AI-assisted imaging and surgical planning tools may offer near-term return on investment potential with lower capital requirements and established FDA clearance pathways. A hypothetical investor would be prudent to consider certain challenges in determining the risk of investing in orthopedic services, such as the evolving Medicare reimbursement rates for physician services and the ongoing scrutiny under federal fraud and abuse laws. However, these challenges seem to be outweighed by the supply-demand gap and the continuing technological advances that improve patient outcomes and operational efficiency.

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