

An Overview of Common Orthopaedic Surgical Procedures and Their Clinical Outcomes

Dr.Sridurga Shravya*1, Mankala Soukya 1, Thakur Nikhil Singh 1, Daravath Pavan Kalyan 1, MD Hanan Shamim Alom 1

Department of Pharmacy Practice, Pulla Reddy Institute of Pharmacy, Annaram(V) Gummadidala (M), Hyderabad-502313, Telangana, India.

Date of Submission: 25-10-2025

Date of Acceptance: 05-11-2025

ABSTRACT:

Orthopedic surgery is a rapidly growing field that treats a wide range of musculoskeletal disorders, which are a major source of global disability. This review article provides a detailed overview of the current landscape of popular orthopedic surgical procedures, including indications and significant breakthroughs affecting modern practice. We begin by discussing the classification of orthopedic trauma, such as the Gustilo-Anderson system for open fractures, and then go into commonly performed procedures like arthroscopy, joint replacement, and external fixation. The article then looks into disruptive technical advancements, particularly robotic-assisted and computer-guided procedures, which improve precision and patient outcomes.

Furthermore, we look at how tissue engineering can help promote bone and soft tissue regeneration. PROMS and pain evaluation are crucial for evaluating therapy efficacy and guiding post-operative care. Finally, we cover essential treatment techniques, including analgesic management. The article suggests that integrating modern surgical techniques, patient-centered outcomes, and changing therapeutic strategies can help restore function, alleviate pain, and improve quality of life for orthopedic patients globally.

Keywords: Orthopedic Surgery, Musculoskeletal Disorders, Gustilo-Anderson Classification, Arthroplasty, Arthroscopy, Robotic-Assisted Surgery, Computer-Assisted Navigation, Tissue Engineering, Patient-Reported Outcome Measures (PROMS), Postoperative Pain Management

I. INTRODUCTION:

The World Health Organization states that osteoarthritis, back and neck discomfort, fractures linked to bone fragility, traumas, and systemic inflammatory diseases such as rheumatoid arthritis are

the most prevalent and limiting musculoskeletal disorders. Restricted mobility and chronic pain are common symptoms of musculoskeletal disorders.[1]

Orthopedic surgery is still one of the most common hospital procedures performed worldwide today, and its prevalence is rising in low- and middle-income nations. The idea of ERAS (Enhanced Recovery After Surgery) programs has had a significant impact on clinical pathways and care programs as the demand for orthopedic surgical operations has grown in light of recent advancements in surgical and anesthesiologic techniques.[2]

It's unclear if popular orthopedic techniques for treating musculoskeletal disorders are supported by solid data. Despite the fact that many musculoskeletal disorders can be treated in primary care by combining fundamental therapies like medication, physical therapy, psychological counseling, exercise, and weight loss, some patients who do not improve with conservative measures require specialized care, surgery, or both.[1]

II. MATERIALS AND METHODS

Classification of Common Orthopaedic Surgical Procedures

Like many classification systems, Gustilo-Anderson schema aims to give surgeons and clinician-scientists a prognostic framework that directs treatment and promotes communication. Decades of studies linking the Gustilo-Anderson type to infection risk have improved surgical techniques, altered antibiotic guidelines, and established the best times for treatments like internal fixation, soft tissue covering, and débridement. The Gustilo-Anderson classification is a well-known and rather simple system that has become the norm for categorizing open fractures. It is also helpful for teaching residents and other

trainees how to treat patients who have experienced orthopaedic trauma.[3]

Gustilo and Anderson divide open fractures into three primary classes according to bone damage, contamination, and wound size.

- An open fracture classified as grade I has little soft-tissue damage and a clean incision that is less than 1 cm long.
- An open fracture classified as grade II has a laceration longer than 1 cm but no flaps, avulsions, or significant soft-tissue damage.
- Open segmental fractures, fractures with significant soft-tissue damage, and traumatic amputations are all classified as grade III. Gunshot wounds, farm injuries, and open fractures with vascular damage that needs to be repaired are examples of special types that fall under Grade III. Because of their diverse injury patterns, significant soft-tissue loss, impaired blood supply, contamination, and fracture instability, grade III open fractures

are the most challenging to diagnose and treat. They are frequently linked to higher morbidity because of the shock and problems that follow these injuries. Between 10% and 50% of Grade III fractures are infected. Grade III fractures are clinically significant since they account for almost 60% of all open fractures.

- Gustilo further separated Grade III fractures into three groups, IIIA, IIIB, and IIIC, to better characterize the severity and prognosis.
- Grade IIIA fractures contain high energy trauma or severe soft tissue tearing, the bone still has sufficient soft tissue covering.
- Extensive soft-tissue loss, periosteal stripping, and exposed bone—typically with significant contamination—are characteristics of grade IIIB fractures.
- An arterial injury that necessitates vascular restoration is linked to grade IIIC fractures.[3]

Grade I	Small low-energy wound, <1 cm no high-energy features
Grade II	Small low-energy laceration over fracture 1–10 cm no high-energy features
Grade IIIa	High-energy open fracture (degloving, periosteal stripping, bone comminution) with adequate soft tissue cover
Grade IIIb	High-energy open fracture with inadequate soft tissue cover
Grade IIIc	Any open fracture with a vascular injury requiring repair for viability

Fig 1: Classification of Open Fracture (Gustilo and Anderson)

Common Orthopaedic Surgical Procedures and Their Indications

Procedure	Main indication
Arthroscopic anterior cruciate ligament reconstruction	Anterior cruciate ligament rupture
Arthroscopic meniscal repair of the knee	Traumatic meniscal tears
Arthroscopic partial meniscectomy of the knee	Degenerative meniscal tears
Arthroscopic rotator cuff repair	Acute rotator cuff tears
Arthroscopic subacromial decompression	Subacromial impingement syndrome
Carpal tunnel decompression	Carpal tunnel syndrome
Lumbar spine decompression	Spinal canal stenosis
Lumbar spine fusion	Degenerative disc disease
Total hip replacement	End stage osteoarthritis
Total knee replacement	End stage osteoarthritis

Fig 2: Common Orthopaedic Surgical Procedures with their Indications

In orthopedic surgery, musculoskeletal disorders—including injuries and illnesses affecting the bones, joints, ligaments, tendons, and muscles—are diagnosed, treated, and prevented. While orthopedic surgery uses a variety of methods, the most frequently used ones include arthroscopy (knee, shoulder, hip, elbow), joint replacement, external fixation, Fusion technique, Osteotomy technology, Bone grafting technique and Soft tissue repair technique.[4]

A. ARTHROSCOPY:

Arthroscopy is a minimally invasive surgical procedure that uses an arthroscope, a tiny camera, to enable a surgeon to see, identify, and treat issues inside a joint. Arthroscopy is also used to treat disorders of the knee, shoulder, ankle, elbow, hip, and wrist.[4]

1. **Knee arthroscopy** is a frequent operation for diagnosing and treating knee issues such as meniscal tears, ACL tears, and cartilage loss. Arthroscopy is also used to treat disorders of the knee, shoulder, ankle, elbow, hip, and wrist.

2. **Shoulder arthroscopy** is used to diagnose and treat shoulder conditions like rotator cuff tears, labral tears, and shoulder impingement syndrome. The surgeon will insert the arthroscope through tiny incisions around the shoulder joint to view and treat any issues. After examining the joint with an arthroscope, the surgeon may use additional tools to fix any damage.

3. **Hip arthroscopy** is used to identify and treat disorders of the hip joint, including labral tears and femoroacetabular impingement. Using tiny incisions around the hip joint, the surgeon will introduce the arthroscope during a hip arthroscopy in order to view and address any issues.

4. Tennis elbow, golfer's elbow, and loose bodies in the elbow joint are among the ailments that can be diagnosed and treated with **elbow arthroscopy**. In order to inspect and correct any issues, the surgeon will perform an elbow arthroscopy by inserting the arthroscope into tiny incisions surrounding the elbow joint.[4]

B. JOINT REPLACEMENT:

Surgically replacing a damaged joint with an artificial joint is called joint replacement, or arthroplasty. Patients with significant joint pain, stiffness, and reduced mobility due to osteoarthritis, rheumatoid arthritis, or injury frequently have it done. Hip replacement, knee replacement, shoulder replacement, ankle replacement, and elbow

replacement are among the several kinds of joint replacement procedures.[4]

Osteoarthritis symptoms and hip femoral neck fractures are the most frequent reasons for hip or knee replacements. Patients are often between the ages of 60 and 70 when they have their initial hip or knee replacement (due to osteoarthritis). Patients over 85 make up more than two-thirds of those undergoing arthroplasty for femoral neck fractures. Revision arthroplasty is the term for further surgery on the same joint, whereas primary arthroplasty is the initial hip or knee replacement. Service life is the amount of time (without complications) that passes between a primary arthroplasty and a revision arthroplasty.[5]

INDICATIONS:

- If a patient's quality of life is significantly impacted by pain or functional disability, a hip joint replacement may be necessary. Other contributing factors include visible causative radiological changes, such as morphological joint damage, which cannot be treated conservatively, and conservative therapies that are insufficiently effective (medication, avoiding strain on the affected joint, physiotherapy, physical therapy, etc.).
- Total knee arthroplasty (TKA) is indicated for both primary and secondary osteoarthritis of the knee if the symptoms are accompanied by radiologically proven severe pain and movement limitations.
- The goal of primary arthroplasty is to minimize pain from osteoarthritis (hip or knee) and associated conditions while restoring joint function as much as feasible. Rapid patient mobilization following femoral neck fractures is another goal. A long service life with adequate weight-bearing capacity and the avoidance of (secondary) problems are additional objectives.[5]

C. EXTERNAL FIXATION:

Although external fixation is used to stabilize many bones throughout the body, the general application method is the same. For structural integrity, the pin-bone interaction is essential. Cutting the skin over the pin insertion point is the first step. In order to prevent inflammation and pin infections, it is important to make sure that no muscle or skin is tenting on the pin. The periosteum can be reflected from the underlying bone with the use of tiny Penfield-type

retractors. To reduce entrapped tissue, a drill sleeve and trocar are advanced to the bone.[6]

INDICATIONS:

For a variety of pathologies, clinicians employ external fixation in pediatric orthopedics, orthopedic trauma, and plastic surgery. Some of the signs for external fixation devices are listed below:

- Unstable damage to the pelvic rings.
- Comminuted periarticular fractures, including those of the elbow, distal radius, tibial plateau, distal femur, and pilon.
- Large-scale soft tissue edema in fractures.
- Fractures in a patient who is unable to have an open operation or who is hemodynamically unstable.
- Long bone fractures that are comminuted.
- Fractures involving a substantial loss of bone.
- Open fractures accompanied with loss of soft tissue.
- Leg lengthening and deformity.
- Loss of bone due to osteomyelitis.
- Joint immobilization following soft tissue flap.
- Arthrodesis.
- Nonunion.
- Malunion.
- Using infection control to help reduce intraoperative fractures. [6]

Advancements in Surgical Techniques

1. Robotic-Assisted Surgeries:

The use of orthopaedic robotic-assisted surgery has grown in popularity because of its potential to increase accuracy, shorten recuperation periods, and better surgical results. At the moment, knee and hip arthroplasties account for the majority of robotic applications in orthopaedic surgery. On the other hand, fracture, shoulder, ankle, and spine care systems have also been established. There are clear benefits and drawbacks to these systems, which have been the subject of more and more research.

Benefits and Results: Enhanced precision, less soft tissue damage, and improved postoperative results are just a few of the benefits that robotic-assisted operations provide. Patients frequently report better joint function, quicker recovery times, and greater levels of happiness overall.

Limitations and Difficulties: Notwithstanding the benefits, there are still difficulties. Widespread acceptance is hampered by high prices, lengthy learning curves, and restricted availability in many areas. Furthermore, not all procedures are now

appropriate for robotic assistance, and the equipment necessitates specific training.

Future Directions: Advancements could involve expanding robotic applications to more intricate orthopedic operations, improving artificial intelligence integration, and using predictive modeling for patient-specific planning.[7]

2. Computer-Assisted Techniques:

Computer-aided navigation systems (CANS), another name for computer-assisted procedures in orthopaedic surgery, are intended to improve surgical accuracy. By combining real-time intraoperative tracking with preoperative imaging data (CT, MRI), they enable surgeons to plan and perform surgeries more accurately than they could with traditional techniques.[8]

Computer-Assisted Navigation Components:

Three key elements are necessary for these systems to function:

- Using imaging data, 3D modeling generates an anatomical model unique to each patient.
- Registration: During surgery, this aligns the virtual model with the patient's real anatomy.
- Real-time navigation reduces mistakes in implant placement and bone cutting by providing highly accurate guidance for surgical instruments.[8]

Applications in Orthopaedic Practice:

Commonly used computer-assisted procedures include

- Total knee arthroplasty (TKA),
- Total hip replacement (THA)
- Surgery for spinal fusions
- Cases of complex trauma

These applications increase functional outcomes, decrease variability, and improve alignment.[8]

Benefits:

- Improved Precision: accurate implant placement and bone incisions.
- Reproducibility: Results from several surgeons and facilities that are consistent.
- Decreased Difficulties: The chance of implant failure is reduced with improved alignment.
- Advantages for Patients: increased function, a quicker recovery, and less postoperative pain.[8]

Obstacles and Restrictions:

- Navigation systems are expensive to install and maintain.

- Surgeons must have specific training.
- restricted availability in environments with limited resources.
- It can be hard to integrate into current surgical workflows.

Future Directions:

- Artificial intelligence integration for decision support and predictive analytics.
- Creation of more affordable, smaller systems for broader use.
- Expansion to include more orthopaedic operations than only spine and joint replacement surgeries.[8]

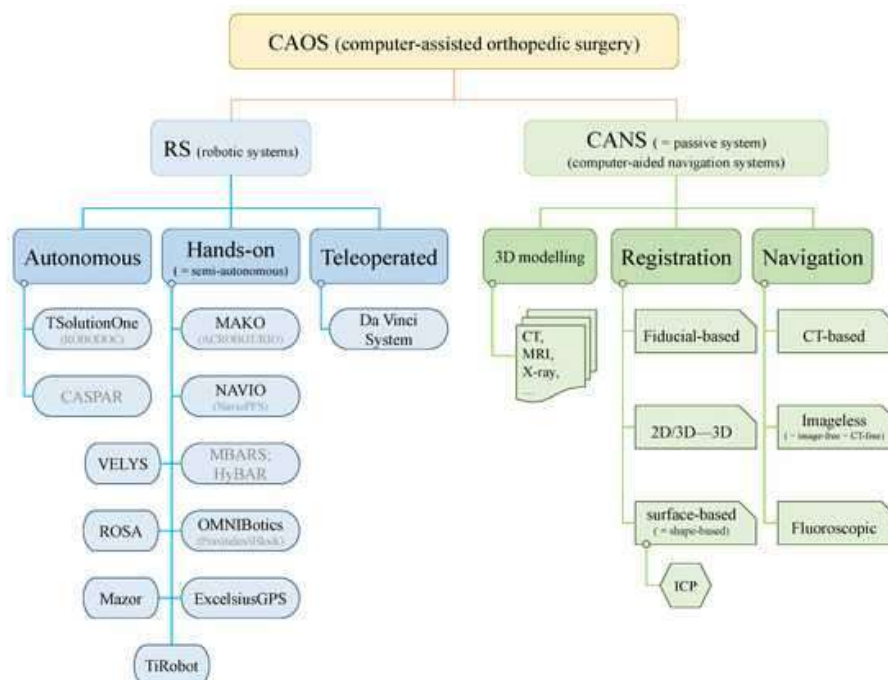


Fig 3: An orthopaedics hierarchical flowchart for robotic systems and navigation methods. The equal symbol "=" indicates "equivalent to," while system names in gray indicate that they are either no longer in use or have been replaced with new ones.

3. Tissue Engineering

Tissue engineering in orthopaedics uses biological, chemical, and mechanical principles to repair or replace injured musculoskeletal tissues such as bone, cartilage, tendon, and ligament. It combines engineered materials and biological agents to encourage regeneration rather than simple repair. It relies on three core components: scaffolds, cells, and signaling molecules.[9]

Scaffolds serve as three-dimensional frames for tissue creation, cells help with regeneration and remodeling, and signaling factors control differentiation and growth. Scaffolds may be natural, synthetic, biodegradable, or permanent. Their structural design tries to resemble the extracellular matrix, which provides mechanical support and promotes nutrition diffusion. Porosity, degradation rate, and biocompatibility are key design factors.

Cells: The capacity of mesenchymal stem cells (MSCs) to develop into osteogenic, chondrogenic, and tenogenic lineages results in their widespread application. Other cell sources include adipose-derived stem cells and induced pluripotent stem cells. Successful regeneration is dependent on the availability and vitality of these cells.

Signaling molecules including BMPs, VEGF, and TGF-β influence cell activity and tissue creation. Effective regeneration is ensured by localized and sustained release through controlled delivery methods.[9]

Clinical applications of tissue-engineered constructions include bone defect reconstruction, cartilage repair, spinal fusion, and tendon/ligament regeneration. Clinical trials show promising structural and functional effects in specific applications.[9]

Challenges include high production costs, immunological reactions, poor vascularization in large creations, and regulatory approval issues. Consistent long-term outcomes and large-scale manufacturing are ongoing problems.[9]

Future Outlook: Biomaterials, stem cell technologies, and bioprinting advancements provide personalized tissue substitutes for patients. The combination of nanotechnology and smart biomaterials is predicted to improve regeneration outcomes.[9]

Patient-Reported Outcomes in Orthopedics

Patient-reported outcomes are important in determining the efficacy of orthopedic treatments, with an emphasis on patients' perceptions of pain, function, and quality of life. These outcomes are captured using a variety of standardized instruments, ranging from general health evaluations to region- or disease-specific measures tailored to specific joints or disorders. Key assessment characteristics include reliability, validity, responsiveness, and interpretability, which ensure that results accurately reflect clinical progress and treatment effects. PROMs are integrated into clinical workflows to help with therapy evaluation, outcome comparison, and long-term patient monitoring. The widespread use of PROMs has highlighted the importance of common frameworks and consistent reporting for meaningful cross-study comparisons.[10]

Emerging initiatives are centered on improving outcome instruments, determining minimal clinically significant changes, and integrating digital health platforms for real-time data collection. In medicine, measurements can be subjective (e.g., patient-reported) or objective (e.g., imaging or lab tests). Patient-reported outcome measures (PROMs), also known as self-report measures, collect information about constructs provided by patients without interpretation by third parties. Patient reported outcomes include perceptions of symptoms, functioning, HRQoL, and satisfaction, among others. PROMs have various focuses, such as generic health-related (e.g., Medical Outcomes Survey Short Form-36), disease/diagnosis-specific (e.g., Western Ontario Rotator Cuff Index), and regionally specific (e.g., American Shoulder and Elbow Society score).[10]

Selecting a PROM for patient monitoring or clinical research requires careful consideration. Empirical evidence suggests that selecting an

instrument based on frequency of usage in the literature does not ensure its quality. For example, in a systematic evaluation of PROMs used in clinical publications of patients after knee arthroplasty, the Knee Society Score (KSS) and the Western Ontario McMaster Osteoarthritis Index (WOMAC) were utilized more. However, a recent rigorous systematic evaluation of PROMs created and tested in patients undergoing or who have undergone total knee arthroplasty discovered that the KSS and WOMAC have less-than-ideal psychometric qualities. Many published clinical studies use invalid, unreliable, and insensitive tools to measure patient outcomes, rendering their conclusions untrustworthy. Further research is needed to fully investigate the hypothesis of knee arthroplasty, as this is only one example in the literature. Orthopaedic surgeons may employ a variety of PROMs to manage patient treatment.[10]

Pain Evaluation:

Pain assessment is an important aspect of the treatment regimen during orthopedic surgery. Acute postoperative pain is difficult to manage and can be fatal if not treated promptly. The pain scale is a simple tool used to assess post-operative discomfort. It asks the patient to rate their pain on a scale of 0 to 10, with 0 representing the absence of pain and 10 being the worst possible agony. The pain scale is simple to assess and has been established for use in postoperative patients.[11]

The Visual Analog Scale (VSA) is another regularly used instrument for evaluating pain. It consists of a 10 cm horizontal line with the phrases "No Pain" on one end and "Worst Possible Pain" on the other. Patients mark over the line to indicate the level of discomfort they are feeling. This scale has been shown to be valid and easy to reproduce for assessing postoperative pain.[11]

In addition to pain scales, individuals can characterize their pain with descriptive phrases such as "oppressive," "burn," "throbbing," or "colicky." The use of these words can assist doctors in determining the cause of the pain and selecting the appropriate treatment. A pain evaluation must include not just the level of pain, but also its location, duration, and consequences on the patient's physical function and quality of life. A pain examination must encompass the psychological and social aspects related to the perception of pain and its response to treatment.[11]

Therapeutic Approaches in Orthopaedic Surgery

Medication	Class	Mechanism of action	Uses
Acetaminophen	Analgesic	Blocks pain signals	Pain relief, fever reduction
Nonsteroidal Anti-Inflammatory Drugs (NSAIDs) (e.g., Ibuprofen, Celecoxib)	Analgesic, Anti-inflammatory	Inhibits COX-1 and COX-2 enzymes	Pain relief, inflammation reduction
Opioids (e.g., Morphine, Oxycodone)	Analgesic	Binds to opioid receptors in the brain and spinal cord	Severe pain relief
Gabapentinoids (e.g., Gabapentin, Pregabalin)	Analgesic	Reduces neuronal excitability	Nerve pain relief
Local Anesthetics (e.g., Lidocaine, Bupivacaine)	Anesthetic	Blocks nerve signals	Local pain relief
Corticosteroids (e.g., Prednisone, Dexamethasone)	Anti-inflammatory	Inhibits immune response	Inflammation reduction
Anticoagulants (e.g., Heparin, Warfarin)	Anticoagulant	Prevents blood clots	Prevention of deep vein thrombosis (DVT)
Antibiotics (e.g., Cefazolin, Vancomycin)	Antibiotic	Kills or inhibits the growth of bacteria	Prevention of infection
Muscle Relaxants (e.g., Baclofen, Methocarbamol)	Muscle relaxant	Reduces muscle spasms	Muscle relaxation during surgery

Fig 4: Medications commonly used in orthopaedic surgery with their class, mechanism of action, and clinical uses.[4]

Acetaminophen

Acetaminophen can be given after surgery to lessen the need for harsher opioid drugs to manage pain. Acetaminophen has no anti-inflammatory qualities because it does not inhibit the COX-1 or COX-2 enzymes, which relieve pain. Used alone, it works effectively for headaches, fevers, and moderate aches and pains, but it does not relieve inflammation and swelling caused by a muscle injury.[11]

Nonsteroidal anti-inflammatory medications

The mechanism of NSAIDs (nonsteroidal anti-inflammatory medicines) has been characterized in terms of peripheral inhibition of prostaglandin synthesis, as well as a variety of additional peripheral and central mechanisms. The central role complements its known peripheral activity, which increases the synthesis of endogenous opioid peptides.

NSAIDs have been shown to be beneficial for musculoskeletal pain, with head-to-head clinical studies finding that NSAIDs provide equal pain relief to opioids while having a lower risk profile. NSAIDs are contraindicated in patients with peptic ulcer disease, chronic or end-stage renal disease, bronchial asthma, and breastfeeding mothers.[11]

Opioids:

➤ Morphine

When basic analgesics fail to accomplish analgesic aims, immediate release opioids are preferable in the therapy of postoperative pain.

Modified-release opioid formulations (including transdermal) should be used with caution because they have been linked to negative outcomes. The advised dose of instant release opioids should be based on age (rather than weight) and renal function. Immediate-release oxycodone is not advised as a first-line opioid since it requires more labor to deliver. However, it is acknowledged that in elderly individuals over the age of 70 or in patients with renal insufficiency, alternative opioids may be administered after surgery.[11]

➤ Oxycodone

Oxycodone, a semisynthetic μ -opioid receptor agonist, has analgesic effects for various pain disorders. Acts on κ -opioid receptors. Oxycodone and morphine are thought to have a 1:1 analgesic potency in postoperative pain after surgery, including both somatic and visceral pain components. Oxycodone is processed by the liver's cytochrome P450 enzyme system. The three most prevalent side effects are constipation (25-30%), nausea (25-30%), and drowsiness (25%), which are similar to those seen with opioids. Vomiting, pruritus, and dizziness occur in 5% to 15% of oxycodone patients. The potency ratio between oxycodone and fentanyl is less than 75:1. The analgesic dose of oxycodone must be reduced in senior patients since metabolic clearance diminishes with age.[11]

III. CONCLUSION

We can conclude that Orthopedic surgery restores function, relieves pain, and improves quality of life for patients with musculoskeletal problems. This overview outlines the essential techniques in orthopedic practice, including the Gustilo-Anderson classification for trauma management and common therapies such as arthroscopy, joint arthroplasty, and external fixation. Understanding the correct indications is crucial for improving patient outcomes and reducing problems. Technological advancements are significantly changing the field. The introduction of robotic-assisted systems, computer-assisted navigation, and improved tissue engineering techniques represents a substantial advancement. These breakthroughs are more than just gradual improvements; they constitute a new era toward unparalleled levels of surgical precision, lower tissue stress, and faster recovery times. These treatments have the potential to regenerate damaged musculoskeletal structures rather than simply repair them.

The use of Patient-Reported Outcome Measures (PROMs) has produced a patient-centered approach that evaluates therapy efficacy based on individual satisfaction, functional restoration, and overall well-being. Thorough pain assessment and multimodal therapy are essential for guiding postoperative care and promoting successful rehabilitation. The future of orthopedic surgery relies on the integration of less invasive procedures, customisation through biologics and bioprinting, and data-driven insights from digital health platforms and PROMs. The integrated, holistic, and patient-centric approach demonstrates the field's dedication to improve both clinical outcomes and the daily lives of patients worldwide.

ACKNOWLEDGEMENT

With great pleasure, we express our profound gratitude to faculties of Department of Pharmacy Practice, Pulla Reddy Institute of Pharmacy, Dundigal, Hyderabad.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ABBREVIATIONS

ACL: Anterior Cruciate Ligament, TKA: Total Knee Arthroplasty, CANS: Computer-aided Navigation Systems, THA: Total Hip Arthroplasty, MSC: Mesenchymal Stem Cells, PROM: Patient-

Reported Outcomes, KSS: Knee Society Score, WOMAC: Western Ontario McMaster Osteoarthritis Index, VSA: Visual Analog Scale, NSAID: Nonsteroidal Anti-Inflammatory Drug.

REFERENCES:

- [1]. Blom, A. W., Donovan, R. L., Beswick, A. D., Whitehouse, M. R., & Kunutsor, S. K. (2021). Common elective orthopaedic procedures and their clinical effectiveness: umbrella review of level 1 evidence. *BMJ*, n1511. <https://doi.org/10.1136/bmj.n1511>
- [2]. Salamanna, F., Contartese, D., Brogini, S., Visani, A., Martikos, K., Griffoni, C., Ricci, A., Gasbarrini, A., & Fini, M. (2022). Key components, current practice and clinical outcomes of ERAS programs in patients undergoing orthopedic Surgery: a systematic review. *Journal of Clinical Medicine*, 11(14), 4222. <https://doi.org/10.3390/jcm11144222>
- [3]. Kim, P. H., & Leopold, S. S. (2012). Gustilo-Anderson Classification. *Clinical Orthopaedics and Related Research*, 470(11), 3270–3274. <https://doi.org/10.1007/s11999-012-2376-6>
- [4]. Liang W, Zhou C, Bai J, Zhang H, Jiang B, Wang J, Fu L, Long H, Huang X, Zhao J and Zhu H (2024). Current advancements in therapeutic approaches in orthopedic surgery: a review of recent trends. *Front. Bioeng. Biotechnol.* 12:1328997. <https://doi.org/10.3389/fbioe.2024.1328997>
- [5]. Seidlitz, C., & Kip, M. (2017). Introduction to the indications and procedures. In Springer eBooks (pp. 1–14). https://doi.org/10.1007/978-3-662-55918-5_1
- [6]. External Fixation Principles and Overview. (2025, January 1). PubMed. <https://pubmed.ncbi.nlm.nih.gov/31613474>
- [7]. Ponna, A. K., Giakas, A. M., Khoudary, A. A., & Siddiqi, A. (2025). Advancements in Robotic Orthopaedic Surgery: a current concept. *SurgiColl*, 3(1). <https://doi.org/10.58616/001c.132487>
- [8]. Li, T., Badre, A., Alambeigi, F., & Tavakoli, M. (2023). Robotic Systems and Navigation Techniques in Orthopedics: A Historical review. *Applied Sciences*,



- 13(17), 9768.
<https://doi.org/10.3390/app13179768>
- [9]. Tataru, A. M., & Mikos, A. G. (2016). Tissue engineering in orthopaedics. *Journal of Bone and Joint Surgery*, 98(13), 1132–1139.
<https://doi.org/10.2106/jbjs.16.00299>
- [10]. Gagnier, J. J. (2017). Patient reported outcomes in orthopaedics. *Journal of Orthopaedic Research®*, 35(10), 2098–2108. <https://doi.org/10.1002/jor.23604>
- [11]. García, L. T. C., Ponce, F. E. E. O., & Esparza, A. C. M. (2023). Postoperative pain in orthopedics. In *IntechOpen eBooks*.
<https://doi.org/10.5772/intechopen.111880>