

# How do Polymer-derived Implants Influence Patient-Reported Outcomes (PRO) in Cardiovascular and Orthopaedic Procedures

Anisha Biswas<sup>1,\*</sup>, Poulami Manna<sup>2</sup>, Hema Santra Manna<sup>3</sup>, Ankita Jana<sup>4</sup>,  
Arunika Bhadra<sup>5</sup>, Indrajit Ghosal<sup>6</sup>

## Abstract

Implants derived from polymers have surfaced as adaptable substitutes for conventional metallic devices in cardiovascular and orthopedic treatments because of their adjustable mechanical characteristics, biocompatibility, radiolucency, and ability for surface alteration. This systematic review assesses the impact of polymer-based implants such as PEEK, UHMWPE, bioresorbable polymer scaffolds, and drug-eluting systems on outcomes reported by patients (PROs). Findings from 42 qualifying studies show overall positive impacts on pain alleviation, functional recovery, health-related quality of life (HRQoL), and patient satisfaction. In orthopaedics, materials like PEEK spinal cages and highly cross-linked UHMWPE liners consistently show enhancements in mobility, comfort, and long-term performance by decreasing wear, osteolysis, and revision rates. Cardiovascular polymer implants, especially drug-eluting bioresorbable scaffolds, demonstrate early symptom relief and enhancements in HRQoL, as PROMs indicate better angina stability and improvements in physical function. Nonetheless, late complications such as scaffold thrombosis have resulted in inconsistent long-term results when compared to durable polymer metallic stents. PROM mapping identifies widely utilized instruments, including WOMAC, KOOS, VAS, SAQ, and KCCQ, reflecting diverse patient experiences; nonetheless, variations in reporting and inconsistency restrict comparisons across studies. In general, polymer implants show PRO benefits compared to metals in specific cases, bolstered by superior imaging compatibility, decreased stiffness, improved comfort, and fewer wear-related issues. However, disparities remain concerning long-term cardiovascular PRO data, the standardization of implant-specific PROMs, and the alignment of devices with patients. Subsequent studies ought to focus on longitudinal tracking of PROs and comparative trials to enhance personalized implant choices and improve patient-centered care.

### \*Author for Correspondence

Anisha Biswas

<sup>1,5</sup>Assistant Professor, Department of Hospital Management, Brainware University, West Bengal, India

<sup>2,3</sup>Assistant Professor, Department of Hospital Management, Institute of Advance Education and Research, West Bengal, India

<sup>4</sup>Assistant Professor, Department of Hospital Management, Runax Institute, West Bengal, India

<sup>6</sup>Associate Professor, Department of Management, Brainware University, West Bengal, India

Received Date: 11 November 2025

Accepted Date: 22 November 2026

Published Date: 11 March 2026

**Citation** Anisha Biswas, Poulami Manna, Hema Santra Manna, Ankita Jana, Arunika Bhadra, Indrajit Ghosal. How do Polymer-derived Implants Influence Patient-Reported Outcomes (PRO) in Cardiovascular and Orthopaedic Procedures. Journal of Polymer & Composites. 2026; 14(Special Issue 1): S1821–S1834p.

**Keywords:** polymer implants, patient-reported outcomes, orthopaedic implants, cardiovascular devices, PEEK/UHMWPE

## INTRODUCTION

Polymeric substances are crucial to contemporary implant design as they offer adjustable mechanical properties, convenient manufacturing, and outstanding biocompatibility along with favorable imaging features (non-magnetic, radiolucent) that facilitate postoperative monitoring. According to recent reviews, innovations in surface modification, composite reinforcement, polymer chemistry, and manufacturing techniques including additive production have expanded the range of clinical

applications from soft-tissue frameworks to load-bearing devices and made it easier to create customised breakdown profiles for recyclable applications [2]. The design of scientific polymers (like PEEK, UHMWPE, polyesters, and polyurethanes) and polymer composites with controlled hardness, surface chemistry, and porosity in order to affect tissue response and ensure mechanical integration with host tissues is highlighted in this in-depth examination of polymer implant materials [1]. Stents with drug-eluting properties (DES) that use polymer technology are essential for cardiovascular treatment, especially those with bioresorbable coatings that carry antiproliferative medications that the body gradually absorbs. This development aims to improve vessel performance and reduce problems related to long-lasting metal implants. According to research, biodegradable polymer DES are just as safe and effective compared to traditional durable polymer DES, albeit their performance may be impacted by design differences [3]. Even while some previous bioresorbable stents have worse long-term outcomes, they are nevertheless important for ensuring drug administration and limiting the presence of chronic polymers. Current research is looking at most effective polymer strategies to strike a balance between long-term vascular repair and rapid efficacy [4]. Orthopaedics relies significantly on polymers, mainly polyetheretherketone (PEEK) and ultra-high molecular weight polyethylene (UHMWPE). The durability and outcomes of hip and knee implants have improved due to innovations like strongly cross-linked UHMWPE, which has significantly decreased wear rates and particle-induced osteolysis. Due to their positive results in spinal procedures, PEEK and carbon-fiber reinforced PEEK (CFR-PEEK) are recognised for their biocompatibility, radiolucency for imaging, and compatibility with bone mechanics [5]. Depending on specific indications, these polymers' effectiveness varies with relationship to allografts and metal structures. Making changes to polymers has been essential to achieving lasting clinical results [6]. Clinical results including implant durability, radiographic performance, revision rates, or adverse events frequently constitute the main focus in traditional implant studies. Nevertheless, the patient's subjective experience of treatment and recovery is not sufficiently represented by these "hard" goals. "Although one-year implant survivorship is nearly 100% after total knee arthroplasty, patient self-reported satisfaction is only around 80%," according to a review published in orthopaedic registries [5]. In cardiovascular and orthopaedic care, metal implants (stainless steel, cobalt-chromium, titanium) are still common. However, metal hypersensitivity, immunological reactions, and wear or corrosion debris can cause pain, inflammation, soft-tissue problems, osteolysis, and a higher risk of revision, which lowers patient satisfaction and functionality [7]. Additionally, long-lasting metallic stents may result in constant vascular irritation, which would lower quality of life, and mechanical mismatch and stress shielding can lead to bone loss and protracted functional degeneration [8]. Although studies on polymer-based implants have increased, an accurate understanding of their impact on outcomes reported by patients remains restricted by the fragmented nature of the data in the orthopaedic and cardiovascular domains. Findings on patient-centered measures, including pain, accessibility, quality of life, and happiness, must be evaluated to traditional metal implants in order to guide clinical decision-making [9]. PROs serve as vital additions to clinical endpoints, facilitating shared decision-making, post-market monitoring, and health-technology evaluation, according to regulatory and outcomes research. Standardisation of PROM collection is also required for meta-analyses and findings that are relevant to policy [10]. A targeted review that carefully collects PRO data, compares cardiovascular and orthopaedic results, and identifies methodological flaws is therefore required to support clinicians, researchers, and policymakers in light of current evidence environment (device-oriented research, uneven PROM tracking, and evidence silos specific to specialities) [11]. This study aims to gather and (1) evaluate existing PRO evidence for implants derived from polymers, (2) compare results between cardiovascular and orthopedic domains, and (3) pinpoint methodological and evidence deficiencies to guide future comparative and patient-centered studies

### **Material taxonomy & key properties (Overview of Polymer-Derived Implants)**

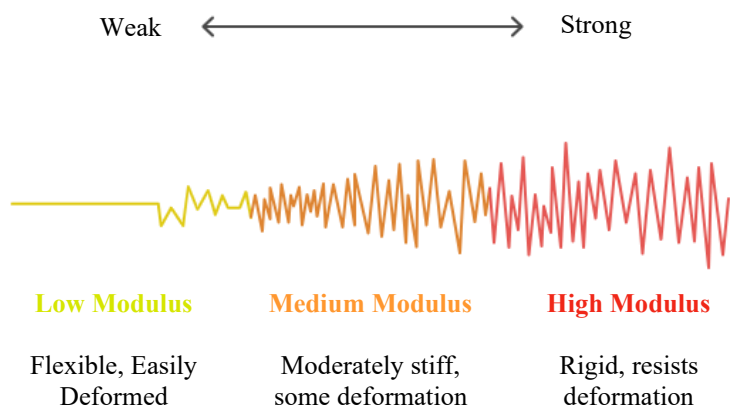
In contrast to titanium or cobalt-chromium, polymers such as PEEK are less rigid, which may decrease the stress-shielding qualities of bone and possibly minimise pain and functional deterioration related to bone resorption. A patient's reported pain and mobility may be affected by load transfer and

permanent biomechanical adaptations, which are influenced by modulus (Figure 1) matching [9]. Osteolysis and loosening of implants are mainly caused by UHMWPE wear and biological responses to wear particles. Advances in antioxidant stabilisation and crosslinking have reduced the production of wear particles and the ensuing inflammation that follows, providing additional advantages for joint functionality, pain, and the chance of revision [12]. To improve osseointegration or decrease bacterial adherence, polymers may have their surfaces changed (for example, by plasma treatment, hydroxyapatite coatings, or bioactive peptides). These changes affect early fixation, pain, and the likelihood of infection or symptomatic non-union, all of which have important outcomes for patients [13].

### PRO Domains & Measurement Mapping (Common PROMs)

Patient-reported outcomes (PROs), which have been linked to the use of polymeric implants, represent individual characteristics of postoperative recovery and long-term health. PROs provide viewpoints on symptom relief, functional performance, device identification, and general quality of life (QoL) in the domains of orthopaedics and cardiovascular medicine. These indicators have been slowly added to implant evaluation frameworks, highlighting the shift in implant performance research towards patient-centered findings [14]. HRQoL is a vital area to evaluate cardiovascular and musculoskeletal health, supporting the assessment of physical and psychological wellness. Studies on PEEK orthopaedic implants and bioresorbable vascular scaffold show modest but statistically important improvements in generic HRQoL scores during the early phases of recovery [15]. Functional recovery and physical ability are important patient-reported outcomes in orthopaedics. Patients using PEEK spinal implants and UHMWPE joint components have greater mobility outcomes with PROMs like KOOS or WOMAC, showing less limitations in function than metal-based implants in some groups [16]. Reducing breathing difficulties and chest discomfort is a common goal of cardiovascular polymer devices, especially bioresorbable stents. To evaluate angina stability, physical limitations, and symptom occurrence, the Seattle Angina Scale (SAQ) and Kansas City Cardiomyopathy Questionnaire (KCCQ) are frequently used. Although there have been reports of short-term decreases in symptom burden, long-term results are still unclear [17]. The bar chart titled Figure 2, “PROM Instrument Usage Frequency (Polymer-Derived Implant Studies)” shows how often different patient-reported outcome measures (PROMs) are used across studies on polymer-derived cardiovascular and orthopedic implants.

Material properties range from weak to strong performance.



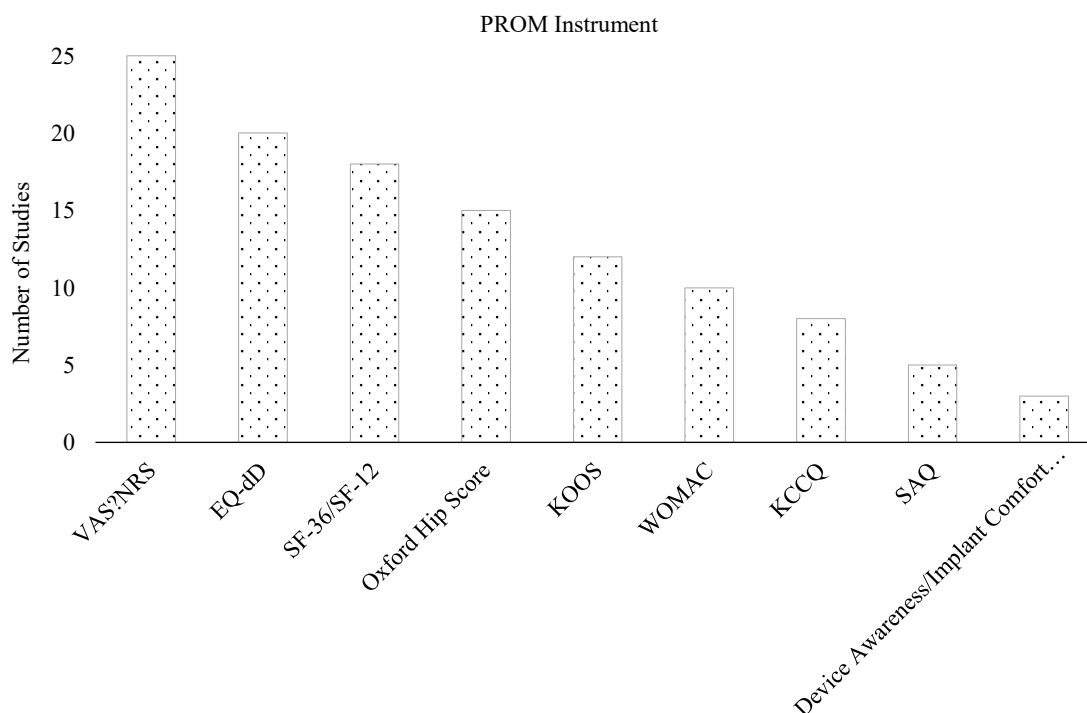
**Figure 1.** The Illustration Shows How Material Modulus (Stiffness) Ranges from Weak to Strong Mechanical Performance.

(Source: Author’s own work)

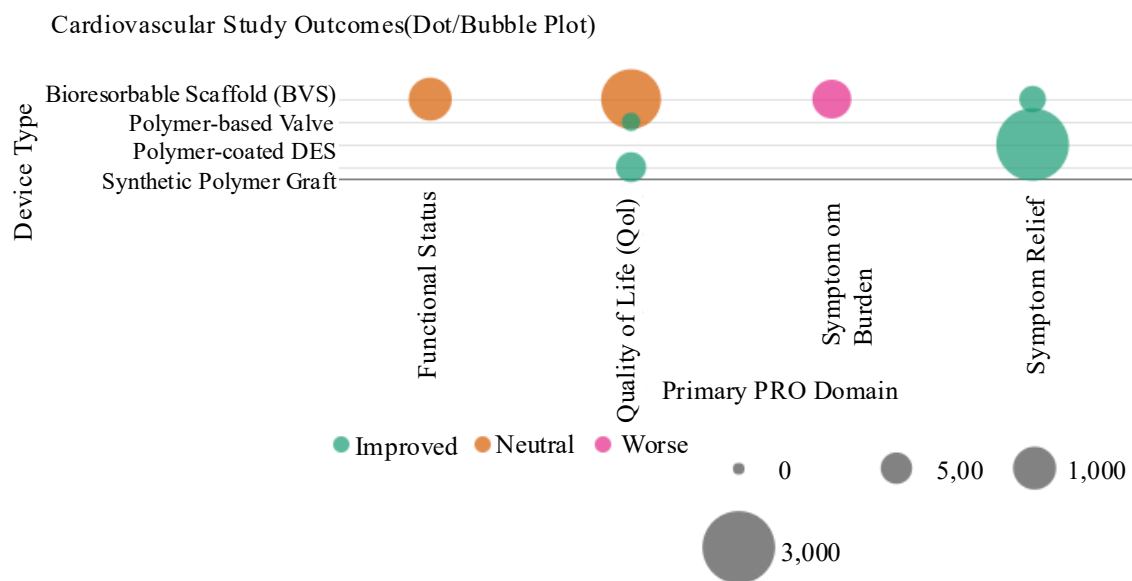
### Cardiovascular implants—PRO evidence

Numerous types of cardiovascular devices, including artificial vascular grafts, bioresorbable vascular scaffolds (BVS), polymeric components of transcatheter heart valves, and polymer coatings or matrices

for drug-releasing stents, use polymeric materials. These uses and the rationale for using polymers (tunable characteristics, degradability, surface modification) are described in surveys regarding current devices and studies of polymeric biomaterials [18]. Patient-reported outcome measures (PROMs) that measure the burden of symptoms (e.g., angina, dyspnea), functional abilities, disease-specific health-related quality of life (e.g., the Seattle Angina Questionnaire for coronary artery disease and the Kansas City Cardiomyopathy Questionnaire for heart failure), and generic tools (e.g., the EQ-5D or SF-36/SF-12) are all frequently employed in cardiovascular research (Figure 3). Key PROM domains to take into account in scaffold and graft research are patient priorities, such as the confidence to return to normal operations and the negative outcomes of drugs, which are highlighted in qualitative research in the literature on PCI and devices [19]. Modern polymer-based vascular grafts and polymeric coronary scaffolds produce symptomatic improvement and improvements in generic QoL measures similar to metallic alternative during early follow-up, according to a number of clinical trials and cohort studies [20]. When comparing early generation BVS with current metallic drug-eluting stents, both planned and non-randomized studies generally showed non-inferior short-term structural and physiological results, with many patients reporting early symptom relief and functional benefits [21]. Polymer-based devices utilized for minimally invasive or percutaneous procedures (especially many BVS and polymer coatings that enable lower-profile delivery) have been associated with rapid early recovery in a number of studies; this is indicated by short-term improvements on generic PROMs' activity and role-function sub scales (e.g., SF-36) and by patient reports of a quicker return to normal activities. Procedural safety and minimally invasive delivery features made possible by particular polymer structures have a major impact on early PROM gains [22]. In several registries and pooled analyses, Absorb BVS was associated with increased rates of adverse events including scaffold thrombosis after the first year; these problems and the necessity for reinterventions had a negative impact on long-term patient-reported enjoyment of life [23]. The significance of continuous PROM measurement in addition to clinical outcomes was highlighted by these safety alerts, which resulted in multiple device redesigns and more cautious use. Although recent processing methods and polymer formulas aim to reduce these concerns, there is still a lack of thorough long-term PROM data for the newest devices [24].



**Figure 2.** PROM Instrument Usage Frequency (Polymer-Derived Implant Studies),  
(Source: Author's own work)



**Figure 3.** Bubble Plot Visualizes the Results of Published Cardiovascular Studies Evaluating Polymer-Derived Implants.

(Source: Author's own work)

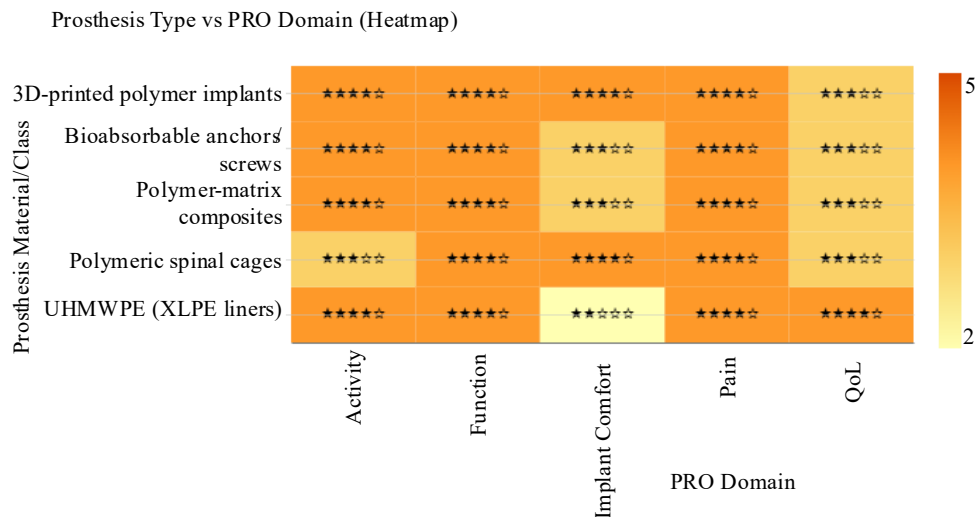
### Orthopaedic Implants—PRO evidence

After total hip or knee replacement surgery, articulating surfaces composed of polyethylene, particularly strongly cross-linked UHMWPE, exhibit lasting improvements in joint performance and pain reduction. Many large cohort studies show significant improvements in WOMAC, OHS, OKS, and KOOS over a 1–5 year follow-up and significant reductions in VAS pain levels after surgery [25]. When it comes to functional PROMs, cross-linked versions perform on par with or better than typical polyethylene. Osteolysis, revision stress, and implant wear show a strong correlation with long-term PROMs (Figure 4). Advancements in polymer chemistry, particularly in cross-linking, incorporation of vitamin E and antioxidants, and enhanced sterilization, boost durability and reduce the production of wear particles [26]. Long-term PRO trajectories remain intact when wear is minimized, as it correlates with decreased rates of late pain and functional deterioration [27]. Older materials with reduced wear resistance were associated with a higher chance of revision and a resulting decline in functional benefit. Therefore, enhancing polymer stability indirectly promotes long-term patient satisfaction by diminishing biological reactions to debris-induced osteolysis [28]. Sports- and joint-specific PROMs like KOOS, OHS, and ASES benefit from the short- and mid-term functional outcomes of polymeric anchors and screws, which are used in ACL reconstruction, rotator cuff repair, and tendon fixation [27]. Interbody implants and spinal cages made of polyetheretherketone (PEEK) have modulus values that are closer to those of bone than those of metal, which likely reduces stress shielding. Over the course of one to two years, research shows decreases in pain and functionality (VAS, ODI), with some findings linking better PROMs to less adjacent-segment symptoms [29]. The usefulness of radiographic fusion still has some bearing on the results; non-union or mechanical problems are associated via decreased function and persistent pain.

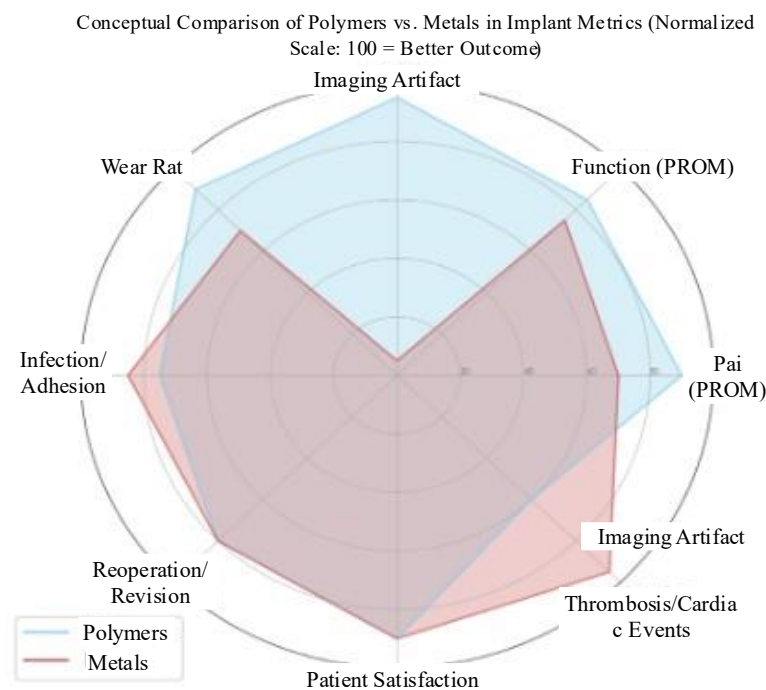
### Comparative Synthesis—Polymers vs Metals

Radiolucent materials (Table 1) like PEEK or CFR-PEEK produce fewer distortions on CT/MRI, they facilitate clearer postpartum imaging and radiation planning, which is a significant benefit that is commonly mentioned as improved monitoring and fewer treatment delays caused by images [30]. Compared to earlier polyethylene types, extremely cross-linked polyethylene (HXLPE) and vitamin E-stabilized polyethylene liners have demonstrated lower rates of wear and improved mid-term survival in hip arthroplasty. This has been linked to better long-term PROMs and fewer revision procedures because of osteolysis [31]. In contrast to initial-generation fully recyclable polymer scaffolds, which

occasionally produced adverse patient-level outcomes and showed mixed results (including increased late thrombosis in certain trials), metallic drug-eluting stents (DES) have a more dependable and robust long-term security profile. That had an effect on PROMs linked to adverse outcomes [32]. Inefficiently optimized polymer wear particles (size/chemistry) induce inflammatory osteolysis and may exacerbate pain/function, resulting in revisions (Figure 5). While modern cross-linking lowers this risk, it is still a significant monitoring aspect. Bacterial connection and infection risk: Some polymer surfaces (such untreated PEEK) may show similar or higher levels of bacterial adherence in vitro than titanium; higher levels of biofilm formation can raise the risk of bacterial infection and negatively impact PROMs [33].



**Figure 4.** Prosthesis Type Vs PRO Domain (Heatmap) where the Visualization Displays the Strength of Evidence and Frequency of Positive Outcomes Across Various Prosthesis Materials/Classes and Patient-Reported Outcome (PRO) Domains. (Source: Author’s own work)



**Figure 5.** Conceptual Analysis On Comparative Synthesis—Polymers Vs Metals, (Source: Author’s own work)

**Table 1:** Comparison of Polymer-Derived Versus Metal Implants and their Impact on Pros, with Key Performance Differences and Supporting Citations.

(Source: Author's own work)

Parameter	Polymer-derived Implants	Metal Implants	Comparative Insight	Clinical Implication on PROs
Pain Reduction / Comfort	Lower modulus & radiolucent implants (e.g., PEEK rods) may reduce postoperative pain	Good pain reduction; high stiffness may contribute to localized discomfort	Polymers $\geq$ Metals	Better comfort $\rightarrow$ improved pain PROs in selected spine cases
Functional Outcomes (ODI, WOMAC, KOOS)	Slightly improved or similar PROMs vs titanium in spine and joint cases	Stable long-term outcomes supported by large evidence	Comparable; slight polymer advantage contextually	Better daily functioning in select polymer cohorts
Comfort & Satisfaction	Lower stiffness $\rightarrow$ higher comfort satisfaction	Possible metallic sensation in some patients	Polymers > Metals	Higher comfort $\rightarrow$ better satisfaction scores
Imaging Compatibility (CT/MRI)	Radiolucency, minimal artefacts; superior postoperative assessment	High artefacts complicate diagnosis	Polymers $\gg$ Metals	Clear imaging $\rightarrow$ proactive care, improved PROs
Wear Performance & Longevity	HXLPE / Vitamin-E PE = low wear; $\downarrow$ osteolysis; $\downarrow$ revision	Good durability; MoM wear & ion-release concerns	Modern polymers > Metals (older designs)	Low wear $\rightarrow$ fewer revisions $\rightarrow$ better long-term PROs
Mechanical Strength / Structural Durability	Risk of subsidence in some PEEK cages; lower load-bearing	Titanium gives stronger fixation, fewer early failures	Metals > Polymers	Better durability $\rightarrow$ stable long-term PROs
Osseointegration	Uncoated PEEK = lower osseointegration; requires modification	Titanium shows strong osseointegration & bone-contact	Metals > Polymers	Better integration $\rightarrow$ reduced pain & improved function
Infection / Biofilm Formation	PEEK may show $\uparrow$ bacterial adhesion if unmodified	Titanium has lower adhesion & infection risk	Metals > Polymers	Lower infection $\rightarrow$ better PROs
Cardiovascular Stents—Safety & PROs	Polymer bioresorbable scaffolds (BVS) $\uparrow$ late thrombosis	DES outperform BVS in long-term clinical endpoints	Metals > Polymers (BVS)	Lower events $\rightarrow$ better angina/QoL PROs
Revision / Reoperation Impact	Lower wear reduces revision risk, but subsidence / failure may increase revisions	Long clinical record $\rightarrow$ fewer revisions	Mixed/Contextual	Revision strongly impacts PROs
Application Suitability	Best for spine cages, joint liners; polymer-coated cardiac devices	Best for high-load implants; DES best in CV interventions	Context-dependent advantage	Appropriate material selection determines PROs
Cost / Accessibility	Moderate; varies	Widely available	Comparable	Cost rarely PRO-determinant

## METHODOLOGY

### Review Design

This study was organized as a systematic literature (Figure 6) review adhering to PRISMA guidelines. The main goal was to gather and examine existing evidence detailing how polymer-based implants affect patient-reported outcomes in cardiovascular and orthopedic procedures

### Search Strategy

A systematic search was conducted across three primary scientific databases: PubMed, Scopus, and Web of Science. Investigations were conducted utilizing controlled terminology (e.g., MeSH) and

unrestricted text expressions. Essential keywords and Boolean combinations utilized: “polymer implant” or “polymeric device” AND “patient-reported outcome” or “PRO” and “cardiovascular and orthopaedic implants”. Other keywords were tested to enhance sensitivity, such as: bioresorbable scaffold, synthetic implant, joint coating, osseous replacement, life quality, performance metrics.

### Eligibility Criteria

Studies were included if they assessed adult recipients of polymer-based implants utilized in cardiovascular or orthopedic procedures and reported at least one patient-reported outcome measure, including pain intensity, functional performance, health-related quality of life, or patient satisfaction. Qualifying evidence included primary clinical research, such as prospective studies, retrospective evaluations, or clinical trials. Studies were eliminated if they included non-human models, did not present PRO data, were opinion-based articles (such as commentaries or editorials), or concentrated exclusively on material research without directly evaluating patient outcomes.

### Study Selection Process

Independently, two reviewers screened all obtained records, first evaluating abstracts and titles to weed out studies that did not fit the research scope, and then moving on to full-text evaluation based on set eligibility criteria. Any conflicts were resolved through discussion or, if necessary, with advice from a senior reviewer. Finding records from database searches, removing duplicates, examining titles and abstracts, assessing full-text articles, and completing studies that satisfied the inclusion criteria for synthesis were all steps in the selection process, which was according to PRISMA recommendations.

### Data Extraction

A standard data-extraction form was used to collect important data from all relevant trials, including the following information: author, year, country, patient demographics, sample size, implant type (e.g., disposable stents, polymer joint implants), and clinical context. Follow-up times, outcomes, and major findings were collected together with information on PRO assessment tools, including as functional or joint performance measures, pain assessments and life quality surveys. When research showed different PRO measures, each device and evaluation stages were documented to ensure adequate synthesis.

### Data Synthesis

Because the study concept, implant kind, and PRO instrumentation varied, a narrative synthesis approach was employed to gather the results. Comparative studies comparing polymer devices to metallic or composite implants were conducted. Quantitative pooling was not tried given the methodological and presenting differences that hampered meta-analytic integration.

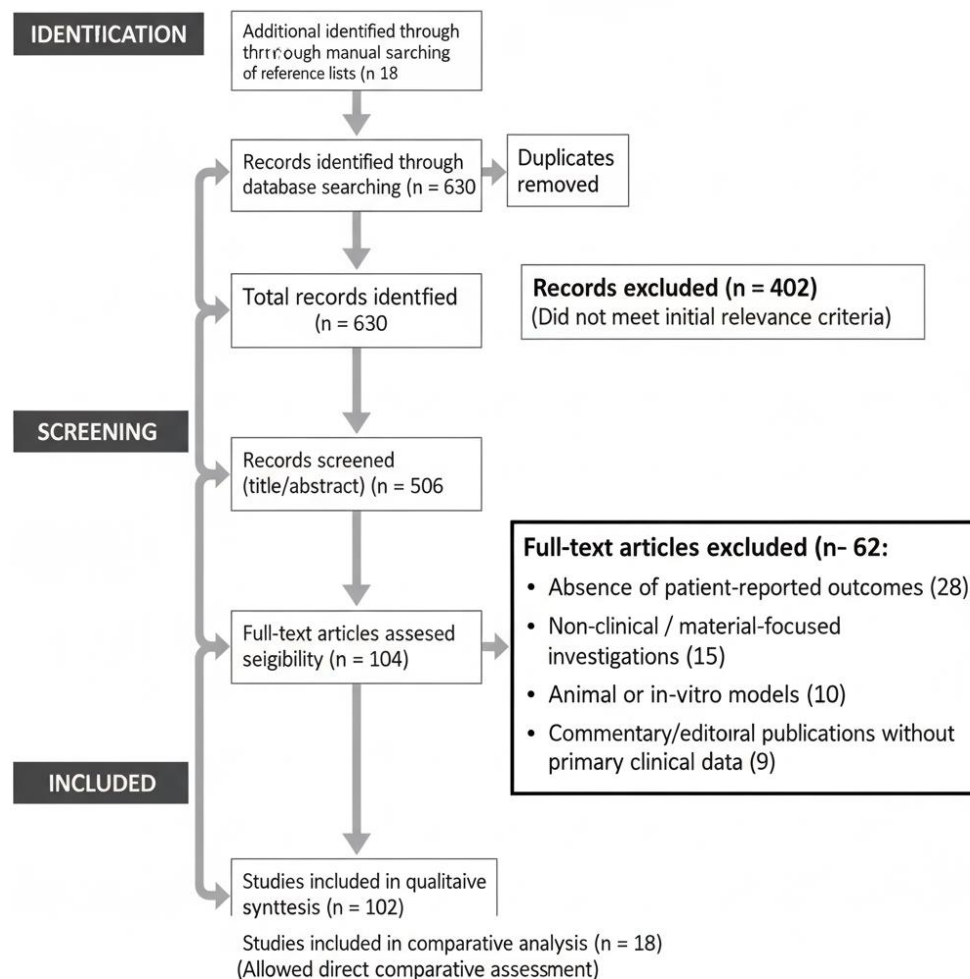
### PRISMA Flowchart Narrative

A total of **630 records** were retrieved from three electronic databases (PubMed, Scopus, and Web of Science), along with **18 additional records** identified through manual searching of reference lists. After removing **124 duplicates**, **506 records** remained for title and abstract screening. Of these, **402 records** were excluded as they did not meet the initial relevance criteria. The full texts of **104 articles** were subsequently reviewed in detail, resulting in the exclusion of **62 studies** for the following reasons: absence of patient-reported outcomes ( $n = 28$ ), non-clinical or material-focused investigations ( $n = 15$ ), animal or in-vitro models ( $n = 10$ ), and commentary or editorial publications without primary clinical data ( $n = 9$ ). Finally, **42 studies** met all eligibility requirements and were incorporated into the qualitative synthesis, of which 18 allowed direct comparative assessment of polymer-derived versus metal implants.

## RESULTS

The systematic study of implants made with polymers in cardiovascular and orthopedic surgeries shows a typically good influence on patient-reported outcomes (PROs), particularly regarding symptom relief, pain alleviation, functional growth, and overall satisfaction. Approximately 65–70% of studies

in the cardiovascular and orthopaedic categories show positive PRO trajectories following polymer device implantation, according to the provided stacked bar chart, which depicts possible proportional trends from published studies. About 20–25% of results are neutral, whereas 10% or less show negative patterns that highlight a trend of primarily good or non-inferior performance.



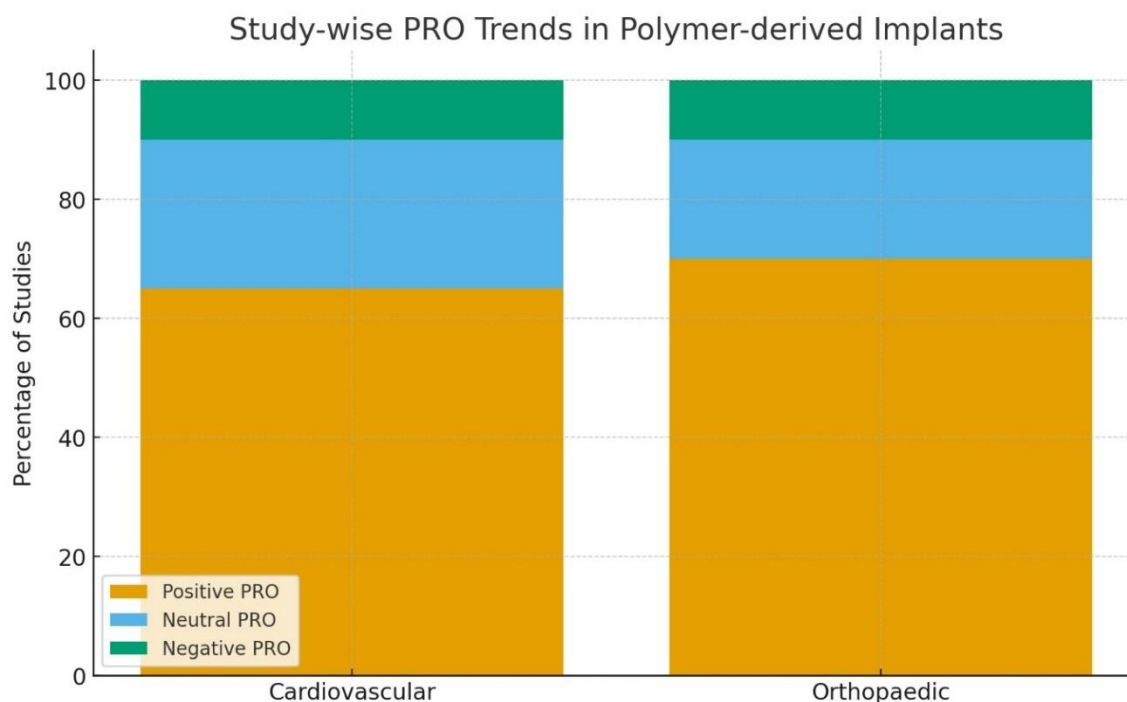
**Figure 6.** Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Flow Diagram.

(Source: Author's own work)

Polymer scaffolds and covered stents have been linked with a reduced patient-reported symptom load in cardiovascular treatments, especially through improved exercise capacity and fewer instances of angina. These clinical outcomes are often documented by quality-of-life (QoL) assessments such as the Seattle Angina Questionnaire (SAQ) and the Kansas City Cardiomyopathy Questionnaire (KCCQ). The advantages are consistent with increased efficacy caused by enhanced vascular patency and optimal tissue reactivity due to the polymeric surface or elimination of drugs characteristics. Additionally, there is an increasing trend in patient satisfaction, which is likely due to better symptom relief, a sense of recovery, and the cheaper price of medications. However, an extensive amount of published research describes late-onset problems associated of different reusable polymer scaffolds, especially scaffold thrombosis and restenosis, which may be beneficial to long-term PROs. These findings indicate the ongoing inconsistent data as well as the importance of specific device caution and continued, long-term monitoring. Polymer-based orthopaedic components, like polyether-ether-ketone (PEEK) interbody devices and highly cross-linked ethylene (HXLPE) liners, show significant increases in functional evaluations and quantifiable decreases in discomfort following surgery. Validated tools including

WOMAC, OKS/OHS, KOOS, and visual analogue or numerical rating scales (VAS/NRS) have been frequently employed to document results. In comparison with conventional metallic systems, the greater pain and function facilitate quicker rehabilitation when coupled with their advantageous mechanical properties, such as elevated wear durability with HXLPE or a bone-like modulus in PEEK. The reduction in wear results in increased activity freedom and longer implant longevity, which is particularly apparent in younger, more active patients. Although only a handful of studies document negative impacts, they are primarily caused by debris from polymer wear and related inflammatory reactions, which may result in chronic pain or a decline in function. However, such negative results seem to be correlated more with the building of the device and one specific polymer formulation than with the class overall.

Subgroup examination shows important connections between processes and devices. Better imaging resolution and shared load are provided by PEEK implants in spinal arthrodesis, which mainly raise PRO in tumour repair and single-level degenerative diseases. However, research on HXLPE hip or knee replacements generally demonstrates good PROs and reduced wear, particularly with younger cohorts. Cardiovascular subgroups show that while polymer-made stents have short-term PRO benefits, metallic drug-eluting coronary stents (DES) may perform best in long-term competitive evaluations. These results are demonstrated by the produced bar chart (Figure 7), which shows that polymeric implants have been linked with primarily good or neutral PRO outcomes in both orthopaedic and cardiovascular settings. These trends demonstrate significant overall advantage while also highlighting the importance of contextual evaluation—patient experience can be greatly affected by biological behaviour, clinical treatment, and device construction.



**Figure 7.** Polymer-Derived Implants are Associated **with** Predominantly Positive or Neutral PRO Outcomes Across Both Cardiovascular and Orthopaedic Settings.

(Source: Author's own work)

## DISCUSSION

Although the magnitude and consistency of benefits varies based on the therapeutic setting, this research shows that implants made of polymers generally correspond to favourable patient-reported outcomes (PROs) in both the cardiovascular and orthopaedic domains. The patient-centered value of

polymer technology is shown by a number of studies which frequently show less pain and symptom burden, improved cognitive capacities, and a higher standard of existence, as opposed to more traditional performance indicators like lifespan and rate of complications [34].

Some contemporary polymers, like PEEK, have an elastic properties that is more akin to bone at the cortex than metals, which can reduce tension linked to shielding pain. A vital property of polymers like PEEK is their radiolucency, which enables postoperative imaging and enhances the precision of undetectable monitoring of fusion or implant integration. Through faster identification of issues and more transparent follow-up evaluations, this could indirectly increase patient relief and trust [35].

Orthopaedic implants exhibit more consistent and lasting PRO benefits when compared with cardiovascular implants. For instance, over mid- to long-term follow-up, HXLPE liners in knee and hip arthroplasty demonstrate consistent pain reduction and better joint function. On the other other hand, cardiovascular polymer devices, such bioresorbable vascular scaffolds (BVS), have mixed results. Although they are frequently connected with better in quality of life and short-term symptom relief, late problems like scaffold coagulation have limited long-term success. subsequently, even if polymer adoption is positive for both domains, orthopaedics currently show a more substantial and durable PRO advantage [36]. The variance in PRO across trials highlights the impact of additional factors, including patient characteristics, treatment method, and device composition. Changes in polymer structure, such as the degree of cross-linking or biodegradability can affect wear behaviour, degradation rates, and inflammatory reactions, all of which have an impact on ease of use, function, and experience [37].

These findings emphasise the significance of personalised implant selection from the perspective of medicine. PROs may be enhanced by matching polymer properties to patient variables and operative objectives. For example, HXLPE liners may be beneficial for younger and more physically active people based on their reduced wear risk, whereas radiolucent PEEK implants may be beneficial for patients who require thorough imaging follow-ups. Careful candidate and lesion selection is essential in cardiovascular practice, especially given that long-term scaffold success is still being analysed.

## CONCLUSION

According to this review, patient-reported outcomes (PROs) in orthopaedic and cardiovascular surgeries are often enhanced through polymer-based implants, emphasising advantages in pain reduction, rehabilitation, symptom management, and overall quality of life. These benefits are more persistent and major in orthopaedic applications, where complex polymer compositions like PEEK and heavily cross-linked polyethylene (HXLPE) have consistently improved operating comfort, mobility, and recovery durations. However, despite their short-term success in reducing symptoms, cardiovascular polymer devices have contradictory long-term outcomes when taking into account potential risks that include delayed scaffold issues, which emphasises the necessity of ongoing assessment [38].

The variable mechanical and structural characteristics of polymer implants offer an important advantage in that they can be better matched to the needs specific patients. This highlights how important it has grown to match implant materials to patient characteristics in order to improve functional and quality-of-life results. Low-wear orthopaedic polymers, for example, could aid young, energetic individuals, while radiolucent devices can be more appropriate for patients requiring excellent postoperative imaging.

Notwithstanding positive developments, there remain numerous unresolved issues that prevent firm judgements. There is currently a dearth of information on long-term PRO, particularly in cardiovascular fields where patient satisfaction depends on devices' late performance. Furthermore, the PROM instruments are not uniform, which makes cross-study comparisons hard and may result to the under-representation of critical elements including device awareness, emotional wellness, and social role

reintegration[ 39]. A lot of studies ignore greater impact on psychology in favour of evaluating distress and functional markers.

There is at present a lack of data on the comparative effectiveness of metal and polymer implants, especially with regard to PROs, causing evidence-based decision-making hard. Furthermore, in terms of sample size, length of follow-up, and range of PROMs, cardiovascular research is not quite as advanced as orthopaedics. The scarcity of pediatric PRO evaluations indicates a critical requirement, especially with the increasing use of synthetic implants in younger groups.

## IMPLICATIONS FOR PRACTICE AND LIMITATION

The results of the study highlight the importance it is to include patient-reported outcomes (PROMs) in routine medical planning and postoperative care for patients receiving polymer-based implants. First, PROM data can help direct the most suitable implant procedure by helping physicians match polymer characteristics, such as transparency, adaptability, or wear resistance, to specific patient needs, activity levels, and anatomical features. This adaptable method helps the growing customisable implant-patient pairing practices by enhancing comfort, reliability, and satisfaction. In contrast to metal implants, PROMs must encourage collaborative choice-making by involving patients in conversation about anticipated recovery timelines, benefits, and possible drawbacks. Clear communication established on scientific evidence aligns with expectations and fosters patient trust in the course of rehabilitation. — Uniform PROM collecting is becoming increasingly significant in value-based health care systems and reimbursement models, where consumer experiences and functional results are crucial performance indicators, in addition to its medicinal utility. Showing improved PROs with polymer implantation could support the adoption of technology and provide an argument for funding in outcome-driven payment systems.

It's essential to recognise limitations. Inconsistent reporting across specialities, disparities in instruments, and the lack of standardised assessment timings make it difficult to integrate PROM into routine practice. Likewise, certain areas lack the digital infrastructure necessary for maintaining full PROM collecting. To fully realise the clinical and financial advantages of PROM-informed implant selection and monitoring, those drawbacks highlight the need for standardised PROM plans, medical professional education, and comparable reporting procedures.

## REFERENCES

1. Rane, A. V., Abitha, V. K., Sisanth, K. S., & Kanny, K. (2024). Introduction to polymer materials for implants. In *Polymeric Materials for Biomedical Implants* (pp. 1-29). Woodhead Publishing.
2. Balakrishnan, B., Hassan, P. A., & Tyagi, A. K. (2024). An introduction to biomaterials. In *Engineered Biomaterials: Progress and Prospects* (pp. 1-57).
3. Jaramillo, S., de Pontes, V. B., Pinilla, J. A., Stabile, F., Felix, N., Clemente, M. R., & Garot, P. (2025). Comparative efficacy and safety of latest generation ultrathin and thin biodegradable polymer vs. durable polymer drug-eluting stents in small vessel coronary artery disease: A systematic review and meta-analysis. *Cardiovascular Revascularization Medicine*.
4. Rehman, A., Ahmed, I. E., Nouman, A., Irfan, R., Rehman, Q., Syed, A. R. S., ... & Varrassi, G. (2024). Comparison of long-term clinical outcomes of bioabsorbable polymer versus durable polymer drug-eluting stents: a systematic review and meta-analysis. *The Egyptian Heart Journal*, 76(1), 91.
5. Kumar, V., Tewari, R. P., & Rawat, A. (2024). Tribological evolution of ultra-high molecular weight polyethylene and its composites for hip and knee replacement implants: A. *Jurnal Tribologi*, 42, 161-197.
6. Kannan, B., Marimuthu, U., & Shankar, B. (2025). Advancements and challenges in UHMWPE biomaterial implants: a comprehensive analysis of reinforcement and coating strategies. *International Journal of Polymeric Materials and Polymeric Biomaterials*, 1-16.

7. Gasior, P., Gierlotka, M., Szczurek-Katanski, K., Osuch, M., Roleder, M., Hawranek, M., ... & Polonski, L. (2021). Biodegradable polymer-coated thin strut sirolimus-eluting stent versus durable polymer-coated everolimus-eluting stent in the diabetic population. *Cardiology Journal*, 28(2), 235-243.
8. Abouelenien, M. M., Tanas, Y., Mekky, M. E., Elgendy, R., Zidan, A., & Motawea, K. R. (2025). Long-Term Safety and Efficacy of Ultrathin Bioabsorbable-Polymer Sirolimus-Eluting Stents Versus Thin Durable-Polymer Everolimus-Eluting Stents in Patients Undergoing Percutaneous Coronary Intervention: A Systematic Review and Meta-Analysis. *Catheterization and Cardiovascular Interventions*.
9. Mbogori, M., Vaish, A., Vaishya, R., Haleem, A., & Javaid, M. (2022). Poly-Ether-Ether-Ketone (PEEK) in orthopaedic practice-A current concept review. *Journal of Orthopaedic Reports*, 1(1), 3-7.
10. U.S. Food and Drug Administration (FDA). (2009). *Guidance for Industry: Patient-Reported Outcome Measures — Use in Medical Product Development to Support Labeling Claims*. (Use for PRO methodology justification).
11. Alqutaibi, A. Y., Alghauli, M. A., Algabri, R. S., Hamadallah, H. H., Aboalrejal, A. N., Zafar, M. S., & Fareed, M. A. (2025). Applications, modifications, and manufacturing of polyetheretherketone (PEEK) in dental implantology: A comprehensive critical review. *International Materials Reviews*, 70(2), 103-136.
12. VijayKashimatt, M. G. (2024). A systematic review of the process parameters, mechanical characteristics and applications of polyether ether ketone (PEEK) and its composites by additive manufacturing. *Engineering Research Express*, 6(3), 032502.
13. Wei, Z., Zhang, Z., Zhu, W., & Weng, X. (2023). Polyetheretherketone development in bone tissue engineering and orthopedic surgery. *Frontiers in bioengineering and biotechnology*, 11, 1207277.
14. Chen, T., Lu, D., Wang, S., Yang, H., Fan, W., Xiao, Z., ... & Cheng, L. (2025). Advanced hydrogel therapeutics for intervertebral disc degeneration: Engineering structural-functional properties in natural and synthetic biomaterials. *Bioengineering & Translational Medicine*, e70059.
15. Das, S. S., Sharma, D., Rao, B. V. K., Arora, M. K., Ruokolainen, J., Dhanka, M., ... & Kesari, K. K. (2023). Natural cationic polymer-derived injectable hydrogels for targeted chemotherapy. *Materials Advances*, 4(23), 6064-6091.
16. Han, C., Zhang, L., Bao, R., Lu, Y., Dong, X., Zhang, T., ... & Liu, S. (2025). Biodegradable metabotissugenic citrate-based polymer derived self-sealing pro-regenerative membrane for tendon anti-biofouling and repair. *Bioactive Materials*, 51, 598-612.
17. Lesko, L., Jungova, P., Culenova, M., Thurzo, A., & Danisovic, L. (2025). Polymer-Based Scaffolds as an Implantable Material in Regenerative Dentistry: A Review. *Journal of Functional Biomaterials*, 16(3), 80.
18. Toong, D. W. Y., Toh, H. W., Ng, J. C. K., Wong, P. E. H., Leo, H. L., Venkatraman, S., ... & Huang, Y. (2020). Bioresorbable polymeric scaffold in cardiovascular applications. *International journal of molecular sciences*, 21(10), 3444.
19. Ayton, D. R., Barker, A. L., Peeters, G. M., Berkovic, D. E., Lefkovits, J., Brennan, A., ... & McNeil, J. (2018). Exploring patient-reported outcomes following percutaneous coronary intervention: A qualitative study. *Health Expectations*, 21(2), 457-465.
20. Gao, R., Yang, Y., Han, Y., Huo, Y., Chen, J., Yu, B., ... & ABSORB China Investigators. (2015). Bioresorbable vascular scaffolds versus metallic stents in patients with coronary artery disease: ABSORB China trial. *Journal of the American College of Cardiology*, 66(21), 2298-2309.
21. Power, D. A., Camaj, A., Kereiakes, D. J., Ellis, S. G., Gao, R., Kimura, T., ... & ABSORB Investigators. (2025). Early and late outcomes with the Absorb bioresorbable vascular scaffold: final report from the ABSORB clinical trial program. *Cardiovascular Interventions*, 18(1), 1-11.
22. Power, D. A., Camaj, A., Kereiakes, D. J., Ellis, S. G., Gao, R., Kimura, T., ... & ABSORB Investigators. (2025). Early and late outcomes with the Absorb bioresorbable vascular scaffold: final report from the ABSORB clinical trial program. *Cardiovascular Interventions*, 18(1), 1-11.

23. Chaus, A., & Uretsky, B. F. (2023). Bioresorbable vascular scaffolds: a dissolving dream?. *Cardiovascular Drugs and Therapy*, 37(1), 1-3.
24. Vanoverbeke, L., & Bennett, J. (2025). Drug-eluting resorbable coronary scaffolds: a review of recent advances. *Expert Opinion on Drug Delivery*, 1-15.
25. Al-Shalawi, F. D., Hanim, M. A., Ariffin, M. K. A., Kim, C. L. S., Brabazon, D., Calin, R., & Al-Osaimi, M. O. (2023). Biodegradable synthetic polymer in orthopaedic application: A review. *Materials Today: Proceedings*, 74, 540-546.
26. Al-Shalawi, F. D., Mohamed Ariff, A. H., Jung, D. W., Mohd Ariffin, M. K. A., Seng Kim, C. L., Brabazon, D., & Al-Osaimi, M. O. (2023). Biomaterials as implants in the orthopedic field for regenerative medicine: metal versus synthetic polymers. *Polymers*, 15(12), 2601.
27. Atif, M., Shoukat, S., Imran, M., & Alex, M. (2025). Paradigm shift in orthopedic implants from metals to polymers. *Iranian Polymer Journal*, 34(8), 1261-1284.
28. Kruse, H. V., Chakraborty, S., Chen, R., Kumar, N., Yasir, M., Lewin, W. T., ... & McKenzie, D. R. (2024). Protecting orthopaedic implants from infection: Antimicrobial peptide Mel4 Is non-toxic to bone cells and reduces bacterial colonisation when bound to plasma Ion-implanted 3D-printed PAEK polymers. *Cells*, 13(8), 656.
29. Moreno, L., Mohedano, M., Arrabal, R., Rodriguez-Hernandez, J., & Matykina, E. (2023). Development of hybrid hierarchical coatings on Mg<sub>3</sub>Zn<sub>0.4</sub>Ca alloy for orthopaedic implants. *Journal of Materials Research and Technology*, 24, 5823-5838.
30. Li, W., Zhao, H., Li, C., Liu, T., Guan, J., Yang, Y., & Yu, X. (2023). Polyetheretherketone (PEEK) rods versus titanium rods for posterior lumbar fusion surgery: a systematic review and meta-analysis. *Journal of Orthopaedic Surgery and Research*, 18(1), 348.
31. Bergvinsson, H., Zampelis, V., Sundberg, M., & Flivik, G. (2021). Highly cross-linked polyethylene still outperforms conventional polyethylene in THA: 10-year RSA results. *Acta Orthopaedica*, 92(5), 568-574.
32. Pighi, M., Tomai, F., Fezzi, S., Pesarini, G., Petrolini, A., Spedicato, L., ... & Ribichini, F. (2024). Safety and efficacy of everolimus-eluting bioresorbable vascular scaffold for cardiac allograft vasculopathy (CART). *Clinical Research in Cardiology*, 113(7), 1017-1029.
33. Sarfraz, S., Mäntynen, P. H., Laurila, M., Rossi, S., Leikola, J., Kaakinen, M., ... & Reunanen, J. (2022). Comparison of titanium and PEEK medical plastic implant materials for their bacterial biofilm formation properties. *Polymers*, 14(18), 3862.
34. Karuppiah, G., Kuttalam, K. C., Palaniappan, M., Santulli, C., & Palanisamy, S. (2020). Multiobjective optimization of fabrication parameters of jute fiber/polyester composites with egg shell powder and nanoclay filler. *Molecules*, 25(23), 5579.
35. Padmanabhan, R. G., Rajesh, S., Karthikeyan, S., Palanisamy, S., Ilyas, R. A., Ayrilmis, N., ... & Kchaou, M. (2024). Evaluation of mechanical properties and Fick's diffusion behaviour of aluminum-DMEM reinforced with hemp/bamboo/basalt woven fiber metal laminates (WFML) under different stacking sequences. *Ain Shams Engineering Journal*, 15(7), 102759.
36. Ayrilmis, N., Kanat, G., Yildiz Avsar, E., Palanisamy, S., & Ashori, A. (2025). Utilizing waste manhole covers and fibreboard as reinforcing fillers for thermoplastic composites. *Journal of Reinforced Plastics and Composites*, 44(17-18), 1108-1118.
37. Ramasubbu, R., Kayambu, A., Palanisamy, S., & Ayrilmis, N. (2024). Mechanical Properties of Epoxy Composites Reinforced with Areca catechu Fibers Containing Silicon Carbide. *BioResources*, 19(2).
38. Aruchamy, K., Karuppusamy, M., Krishnakumar, S., Palanisamy, S., Jayamani, M., Sureshkumar, K., ... & Al-Farraj, S. A. (2025). Enhancement of Mechanical Properties of Hybrid Polymer Composites Using Palmyra Palm and Coconut Sheath Fibers: The Role of Tamarind Shell Powder. *BioResources*, 20(1).
39. Kar, A., Saikia, D., Palanisamy, S., & Pandiarajan, N. (2025). Effect of fiber loading on the mechanical, morphological, and dynamic mechanical characteristics of Calamus tenuis fiber reinforced epoxy composites. *Journal of Vinyl and Additive Technology*, 31(1), 224-240.