

# PEEK Performance: Polymer Knee Implants Give Metal a Run in Early TKA

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**H**ealthcare providers performed around 3.6 million knee replacement procedures globally in 2023, as per LSI's Global Procedure Volumes Database, which covers 37 countries. This substantial volume highlights the massive clinical demand and shows a strong opportunity to innovate beyond traditional metal-on-polymer implant technologies. As more people age and joint problems from lifestyle become more common, the orthopedic field is turning to new, improved solutions that better meet what patients and healthcare systems need today. Will all-polymer implant technology drive the next breakthrough in total knee arthroplasty (TKA)?

## Wear data now suggests metal may no longer set the pace in TKA?

Healthcare community widely regards metal-on-polymer implants as the gold standard in TKA as these implants effectively handle the knee joint's high load-bearing demands. Compared to all-polymer alternatives, metal-on-polymer designs provide greater mechanical strength, enabling them to withstand daily use and maintain long-term joint stability. According to the American Academy of Orthopedic Surgeons, **~90% of total knee replacements continue to function effectively 15 years after surgery.**

**Maxx Orthopedics** and **Invibio** (a **Victrix PLC** company) are **set out to challenge this conventional view** with the Freedom Total Knee System using PEEK-OPTIMA femoral component (PEEK standing for Polyether Ether Ketone).

In 2025, a research study (Cowie et al., *Bioengineering* 2025, 12(3):261) reported that PEEK-OPTIMA polymer-on-UHMWPE (Ultra-High-Molecular-Weight

Polyethylene) knee implants showed UHMWPE wear comparable to metal-on-UHMWPE. Researchers based this conclusion on their evaluation of PEEK-OPTIMA and cobalt-chrome femoral components paired with a polyethylene lower knee component in a knee simulator mimicking real walking and movement. Findings from this study address the key concern that all-polymer knee implants might wear out too fast.

Another research paper (ORS 2025 Annual Meeting Paper No.275) concluded that **the wear behavior (including wear factor, rate, and volume) of PEEK-on-UHMWPE was comparable to cobalt-chrome-on-UHMWPE and met ASTM (Advancing Standards Transforming Markets) wear standards.**

Overall, the collective evidence demonstrates that all-polymer **PEEK implants could match the wear performance of metal-on-UHMWPE systems** over millions of cycles, alleviating concerns about rapid degradation. Further research and clinical trials must still confirm real-world durability.

## **A polymer shift could reshape knee implants if the promise holds**

PEEK's practical advantages are vast and include **faster manufacturing, onsite customization, lower allergy risk, clearer imaging, and better bone compatibility.** This could address longstanding issues with metal-based knee implants and reshape the TKA landscape, potentially becoming the new benchmark for knee implant materials.

### *Shorter lead times could make knee implants cheaper to deliver*

Studies show that manufacturers can injection-mold PEEK components in about three minutes and can have them ready for use within a week. This is in contrast to custom cobalt-chrome pieces, which often require months to finish. This **rapid production cuts manufacturing costs** and reduces hospital inventory requirements, **making implants more affordable and improving access for patients facing long waitlists.** Surgical centers can also benefit from greater flexibility to adjust designs quickly.

If PEEK adoption grows, patients, healthcare providers, payers, and PEEK producers will surely benefit. However, **traditional metal-implant makers would face major disruption,** forcing them to adapt or partner with polymer experts to stay relevant.

### *On-site 3D printing could bring knee replacement closer to fit*

PEEK's compatibility with high-temperature **3D printing allows hospitals to create patient-specific implants on demand**. Such implants can fit the anatomy more precisely, potentially improving recovery and function. On-site implant printing also eliminates shipping delays and the need for large warehouses for hospitals and solution providers.

However, **acquiring industrial-grade PEEK printers and training staff requires significant investment**, which will likely act as a factor slowing adoption. On the supply side, implant makers will be challenged with additive manufacturing (which they will likely have to bring in-house) and the need to forge partnerships with 3D-printing players. All players, whether established or start-ups, will have to navigate strict and demanding regulatory approval before hospitals adopt these materials.

### *Metal-free implants could reduce allergy-related knee revision risks*

As PEEK does not release metal ions into surrounding tissue, it **eliminates the risks of irritation or hypersensitivity** that affect up to 25% of patients with implants. This is a considerable benefit for patients with metal allergies. **Hospitals may see fewer allergy-related follow-ups, fewer revision surgeries, and lower long-term costs**. This is again challenging metal-implant makers. They will have to address this shift by developing hypoallergenic alternatives or risk losing market share as patients and healthcare professionals move to polymer-based options.

### *Clearer scans could make polymer knee implants easier to monitor*

**PEEK's radiolucency produces clear standard imaging (X-rays, CT scans, and MRIs)** without metal artifacts, enabling earlier detection of misalignment, loosening, or infection. This means a reduced need for specialized scans, lowers costs, and radiation exposure. Change in implant materials will **affect radiology solutions vendors**, as they may have to adjust protocols to optimize scans for polymer implants.

### *Bone-like mechanics could help knee implants preserve surrounding bone*

**PEEK is isoelastic** and mimics the mechanical properties of natural bone, spreading pressure more naturally through the bone around it. This **reduces stress shielding that can cause bone loss around stiffer metal implants**. Patients may experience fewer long-term complications and easier revision procedures if needed.

Those **bone-friendly mechanics offer a great benefit for several hospitals and payers**, thanks to lower costs of managing bone-loss issues. Implant developers must consider whether newer low-modulus metal alloys can match PEEK's bone-preserving properties at all, as polymer-based solutions can redefine TKA standards.

Considering these benefits, **PEEK presents a compelling alternative to metal-based knee implants**. Each benefit comes with practical considerations, including upfront equipment costs, regulatory challenges, and strategic shifts for established manufacturers. As clinical trials progress and real-world data accumulate, stakeholders across orthopedics will need to monitor the impact PEEK will have on reshaping the implant market.

### **Trials and approvals suggest all-polymer TKA is nearing market**

FDA Investigational Device Exemption (IDE) approval, global feasibility trials, and dedicated research funding signal that PEEK-based knee implants are on the verge of commercialization.

#### *FDA IDE approval has moved polymer knee implants into clinical testing*

In September 2024, the **FDA granted an IDA for the Freedom Total Knee System using Invibio's PEEK-OPTIMA femoral component in partnership with Maxx Orthopedics**. This authorization clears the way for systematic safety and efficacy data collection under controlled conditions. IDA gives legitimacy to the solution, and hospitals and surgeons can begin preparing for a polymer-based alternative entering the mainstream in the future.

#### *Years of joint development leave polymer knee production closer to scale*

Invibio recognized PEEK's medical potential in the early 2000s, and by 2024, over 15 million PEEK-OPTIMA devices were implanted worldwide. Since 2012, **Invibio and Maxx Orthopedics have co-developed an all-PEEK femoral component paired with a UHMWPE tibial insert**. Invibio can probably consider scaling its existing PEEK production facilities (although it already maintains large-scale PEEK-OPTIMA manufacturing facilities). Similarly, other PEEK producers might follow suit to offer reliable availability and cost predictability once approvals are in place. Incumbent metal-implant manufacturers may need to forge similar partnerships or invest in polymer capabilities to avoid losing market share.

#### *Early trials point to safe use, but bigger studies still matter*

Several feasibility studies in, ongoing since 2021, have shown no device-related adverse events with the PEEK-OPTIMA component in small patient cohorts. This suggests **strong biocompatibility and mechanical resilience**. Healthcare providers will continue watching further study results and might alter their component purchasing decisions. Established TKA suppliers will face renewed pressure to rethink their own implant solutions if studies show continued positive results.

### *India could give polymer knee implants their first real market test*

Maxx Orthopedics plans to file for **regulatory approval in India with a 2025 commercial launch target**. India's large patient base and growing demand for joint replacements create an ideal environment for initial commercialization. For players, **early market entry here could build clinical experience and generate real-world data** to support subsequent approvals in Europe and the USA.

### *Academic backing should help prove where polymer knees work best*

In 2023, **Invio and academic partners secured a £1.7 million UK EPSRC grant for TKA patient outcome research**. This funding will support ongoing research into wear patterns, revision rates, and other outcomes. **Robust academic data will likely affect clinical decisions and payer coverage**, while boosting evidence for PEEK implant solutions makers.

The momentum around all-polymer TKA continues to grow, thanks to regulatory milestones, scientific studies, strategic manufacturing alliances, and academic validation.

## **EOS Implic-Action: Polymer knees could force metal leaders to move faster**

The ongoing developments from Invio and Maxx Orthopedics mark a potentially transformative era in TKA, moving beyond conventional metal-on-polymer implants. However, all-polymer implants have yet to reach a point where they can directly compete with metal implants, which have demonstrated reliable durability over five decades. Although PEEK shows promise as a metal-free alternative, **additional real-world studies are needed to validate its long-term effectiveness**.

Nevertheless, the emergence of all-polymer knee implants will likely prompt a counter-response from incumbent players, further accelerating innovation in

the field. The stakes are high, as LSI's Global Market Analysis & Projections database shows that **Zimmer Biomet, Stryker, and DePuy Synthes still dominated the TKA market in 2023, collectively accounting for about 80% of the overall market.**

Zimmer Biomet, for instance, in March 2025 secured FDA clearance of Persona Revision SoluTion Femur, a revision knee implant component made of Titanium (Ti-6Al-4V) alloy, offering an alternative for patients with metal sensitivities. This development reflects their **strategic effort to address concerns around metal allergies and to strengthen their trusted metal implant offerings** to stay competitive.

**Most established market players have the know-how and infrastructure to drive R&D** in all-polymer implants for TKA, given their experience with implant polymer technologies and the inclusion of PEEK-based implants within their broader portfolios and other applications. For instance, both Zimmer Biomet and Stryker successfully commercialized customized solutions for PEEK-based cranial implants. Their existing R&D pipelines and clinic networks position them to act fast. With this, they might be **able to considerably stifle disruption from startups or niche players.** The challenge for these large companies will likely be the execution.

Smaller competitors often innovate faster, while established players can be slowed by internal processes or reliance on existing metal implant revenue streams and supply chains. How they handle this transition will shape the future of knee replacements, **either reinforcing their market leadership or allowing newer companies to gain a foothold.**

